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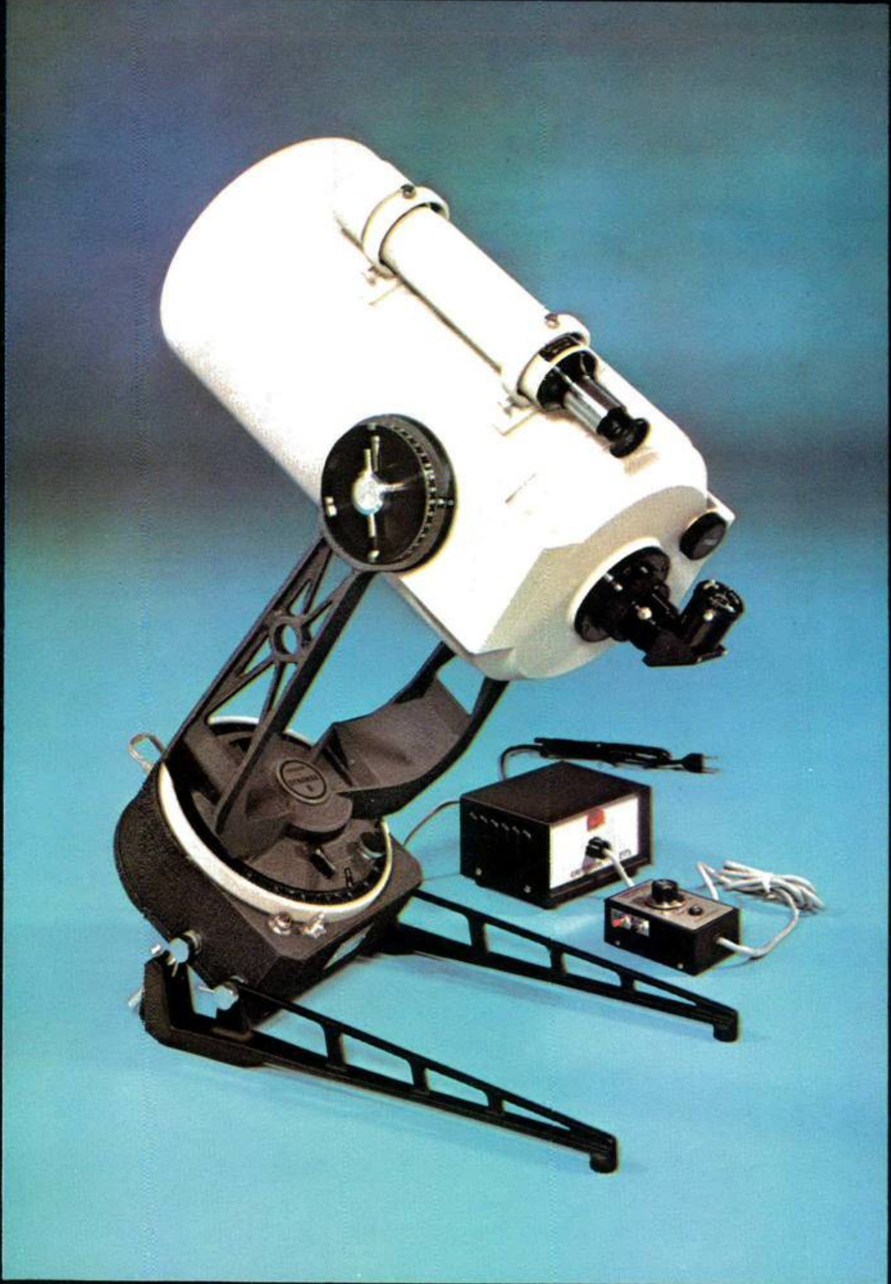

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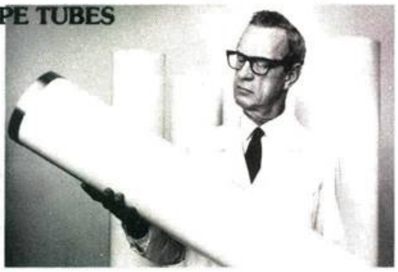

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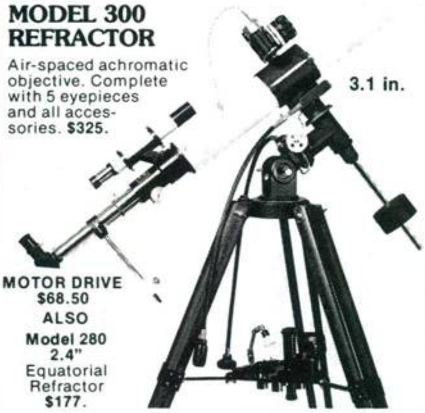

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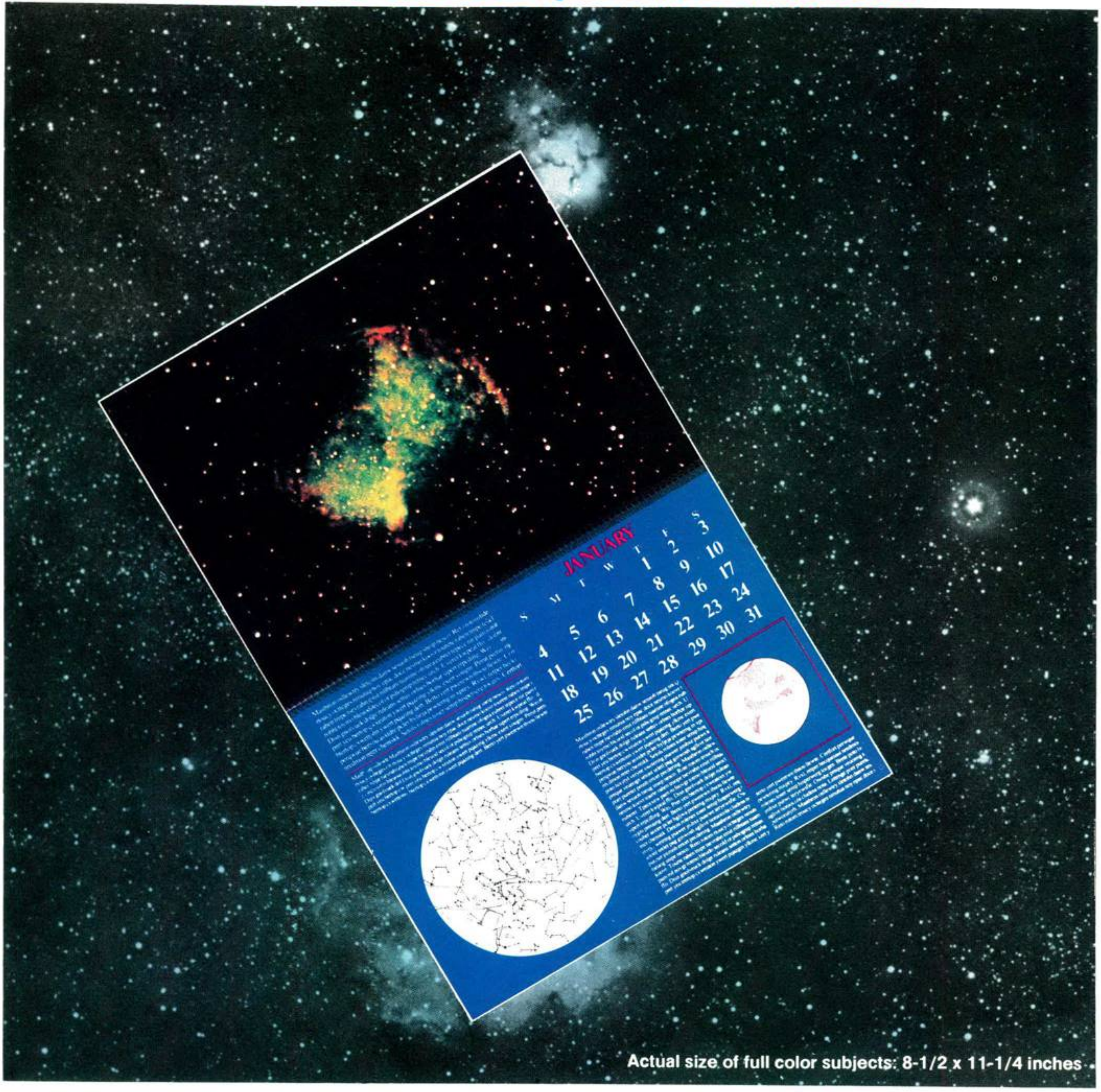

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December 1975 Vol. 3, No. 12

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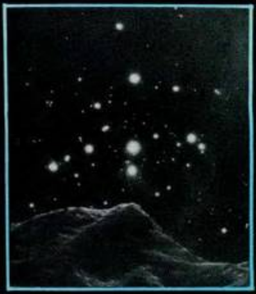

Cover

If you'd like to take a "far out" trip this winter, why not visit the luminous stars of the Pleiades star cluster? These massive stellar youngsters — only 20 million years old — shine so brightly in Earth's sky you'd hardly guess they're 500 light-years distant. Yet the light from the Pleiades you see this month started its journey to Earth before Columbus discovered America. Expand your mind a bit — imagine you're on a planet in the vicinity of Pleione. Maybe this is what the Pleiades would look like. To find the Pleiades star cluster, see this month's Star Dome. Artwork by Adolf Schaller.

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ASTRONOMY FROM THE MOON

by

James E. Oberg

Man long ago dreamed of the moon and stars beyond his reach. His vision was hampered by the limits of his eyes, and his perspective by Earth's interference as he tried to find meaning in the puzzling, changing sky. But his ingenuity was not thwarted. With mechanisms, lenses, other schemes and devices, Earthbound astronomers probed the heavens.

One Christmas eve a few years ago, man's dreams at last seemed within reach. The moon-orbiting Apollo 8 astronauts had visited another world in space. Like Earthbound ancients, they too examined the sky above them. Astronomy from the moon had begun.

Decade by decade astronomers have improved the location of their observatories. From riverbank to rooftop, from the ziggurat to the mountaintop, generations of stargazers searched Earth seeking a better base for their sky studies. Within this century, observations have been made from a host of devices — balloons, aircraft, rockets, and now satellites. The Space Age opened vast new vistas for astronomy. Telescopes in orbit have studied the sun and stars in ways denied to surface dwellers. The awesome revolution in vision has literally opened man's eyes to the sky.

Searching for a better vantage point may not have ended with Earth orbit. Many specialists claim that Earth orbit is still not good enough for certain observations, and a further journey is necessary.

In a never ending search for better understanding of the universe, man brought his hopes to the moon. That Christmas eve in 1968, as Apollo 8 orbited our satellite, the astronauts examined the sky above them and began astronomy from the moon. Photograph by John Sanford.

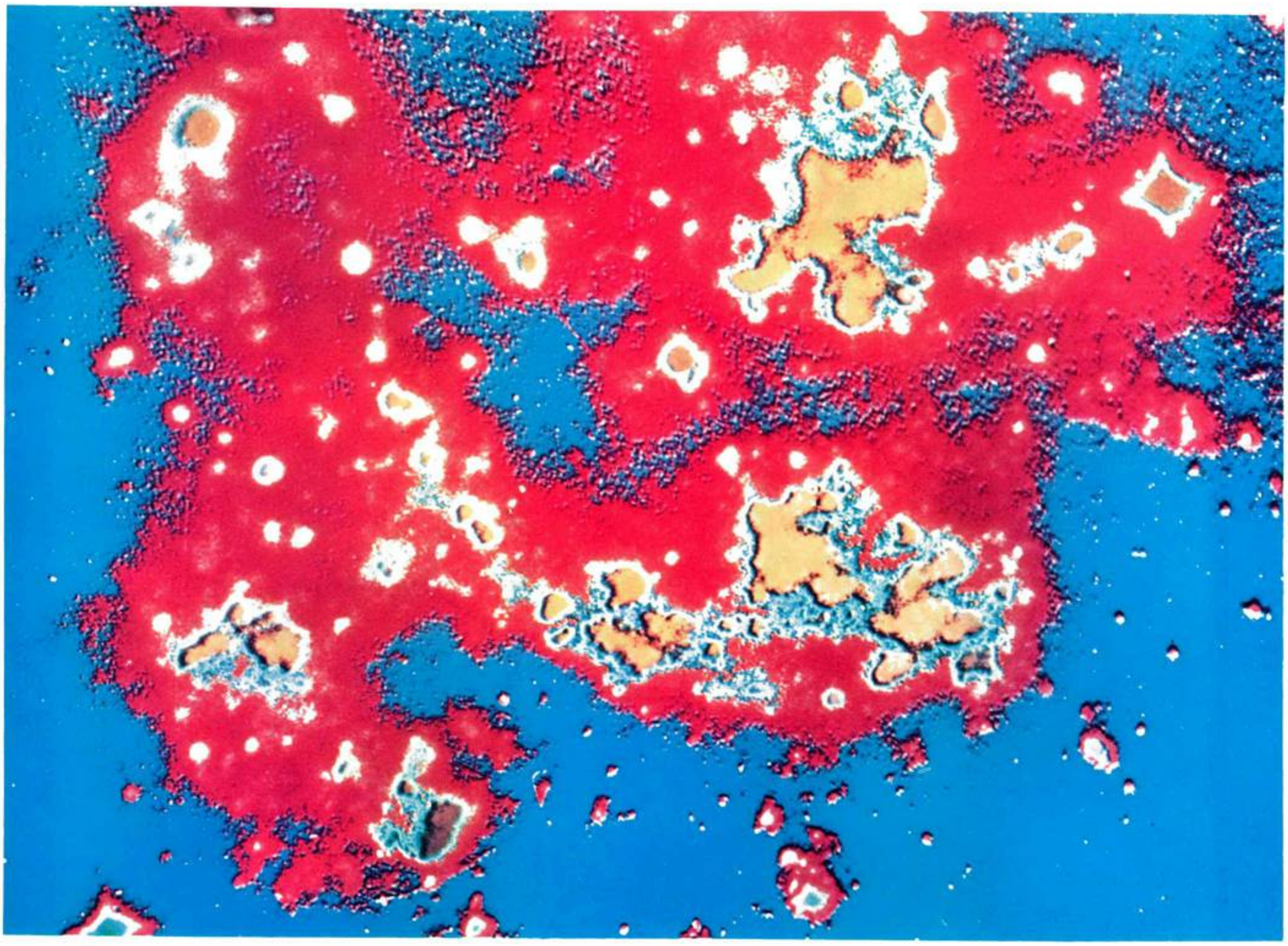
These targets of observation, say the specialists, must be studied from the moon. Astronomical observatories on or near the moon may well be needed to supplement the LSTs (Large Space Telescopes), HEAOs (High Energy Astrophysical Observatories), and ATMs (Apollo Telescope Mounts) a few hundred miles above Earth.

What observations might justify the tremendous additional cost of new moon voyages? How do orbital versus lunar environments compare for astronomical equipment? What discoveries await the lunar observatories, and at what cost? Is astronomy a compelling reason to return to the moon?

Strictly speaking, the study of the moon is a classic aspect of Earth based astronomy, and lunar probes have continued this study during flyby missions, collisions, soft landings, orbital reconnaissance, and ultimately manned visits. But an operational definition of lunar astronomy will exclude lunar observation from the scope of activity. Lunar astronomy will be directed toward the skies, sun and stars, and importantly toward a new celestial body, Earth.

Actually the first astronomical observations from the moon were made in June 1966 when the American robot spacecraft Surveyor 1 landed successfully. Although its primary mission was to examine the lunar surface in preparation for manned landings, the vehicle's television cameras were multipurpose. After sunset on the first lunar day, ground controllers turned the camera to the west and observed solar coronal streamers. Faint stars appeared in the images from the moon.

The following year, other Surveyor spacecraft twice observed eclipses of the sun by Earth. On April 24 and Oct. 18, 1967, the moon robots measur-



A close galaxy outside our Milky Way is the Large Magellanic Cloud. The color-enhanced ultraviolet light portrait above, taken by Apollo 16 astronauts on the moon, reveals only very hot stars and their spiral-like distribution. Blue represents black sky; red designates faint nebulae and stars; the other colors which vary in degree of saturation indicate areas in the Large Magellanic Cloud that appear "bright" to ultraviolet light. The opposite page shows a normal visible light photograph for comparison. Above: NASA photograph. Opposite: Lick Observatory photograph.

ed the temperature drop as the moon passed through Earth's shadow. Television cameras viewed the terrestrial halo created along Earth's periphery by sunlight diffraction in the atmosphere. A few months later, another TV camera caught the light of a laser beam projected onto the moon from the darkened North American continent. Manmade robots — but not yet men — lifted their eyes skyward from our second world.

Even before the opening of the Space Age in 1957, thoughtful observers had predicted the moon would someday provide men with a better base for astronomy. The absence of atmospheric distortion was one obvious advantage. Then, too, most of the electromagnetic spectrum is blocked by Earth's atmosphere.

But most of the gains originally listed for moon based observatories could have been just as easily satisfied by telescopes in Earth orbit only a few hundred miles high. By necessity, this was the approach during the first decade of space exploration. At the same time, flights to the moon were also being planned — but not for astronomical purposes. New justifications were needed for astronomy from the moon.

By 1970, two specific astronomy experiments which required lunar flights had been developed. Planning for the missions began. While the orbiting geophysical, solar and astronomical observatories carried out important work from Earth orbit, two projects were prepared to do astronomy from the moon — the Radio Astronomy Explorer (RAE-2) and the Extreme Ultraviolet camera/spectrograph. Both would carry out experiments and make observations which would be impractical or impossible to do closer to Earth. The moon was a convenient location with unprecedented advantages for these activities.

In planning the experiments, space design engineers were faced with a number of difficult technical problems. What pointing accuracy was needed, and what kind could be achieved? How would data be returned a quarter of a million miles to Earth? How would the devices be controlled? What temperature, gravitational, particle and radiation environments would be encountered, and how long would each apparatus have to survive them? How could the extra mission costs be balanced against extra or unique capabilities?

In the first example, radio astronomy from Earth or Earth orbit faces two problems — the manmade background noise in certain wavelengths of astronomical interest, and the natural radio noise of Earth's ionosphere and magnetosphere. To overcome the former problem, instruments could be hidden behind several thousand miles of rock. The latter problem could be solved by removing the receivers several tens of thousands of miles from Earth. The moon promised to serve both these needs quite well.

The object of such an experiment would be to study radio waves in the decameter and kilometer wavelengths. They are important because they contain information concerning nonthermal radio sources. But Earth's magnetosphere — along with standard radio broadcasts from commercial stations — causes severe interference for near-Earth receivers. The radio signals are essentially caused by *synchrotron radiation* of fast-moving electrons in magnetic fields, as well as by other less understood phenomena. Jupiter is the most intense source of kilometer waves, along with the sun and the solar atmosphere. Other receptions have been reported from Saturn, and theoretical studies suggest that Uranus should also be emitting radio signals at these wavelengths.

To study these signals, a Radio Astronomy Explorer was sent into lunar orbit in June 1973. Named Explorer 49, the 736 pound robot spacecraft unfurled straight wire antennas 750 feet across, and tuned in on radio signals. The satellite circles the moon once every 3-3/4 hours at an altitude of about 700 miles.

Since the instruments' resolution is not accurate, only a rough idea of the radio source's location can be obtained. To determine the location much more accurately, the satellite uses occultation of the target by the moon's horizon — which occurs twice in every orbit. Two curves are obtained showing where the radio signal suddenly ceased; the point where the arcs intersect is the source.

Using this technique, the signals have been studied from the sun, Jupiter and other celestial objects, as well as the general background level of radio noise. Earth's magnetosphere and auroral activity have been measured, along with activity in the sun's outer atmosphere between 10 solar radii and Earth's orbit. The solar corona can also be studied by observing its weakening of signals from Jupiter. In theory, other radio activity sources in the solar coronal plasma could be located by using a more sensitive instrument to measure the interference between direct signals and signals reflected off the upper layers of Earth's ionosphere. None of these studies could have been made as well from near Earth. The moon's distance from Earth, and its availability as an occulting device, make it a valuable location for this kind of radio astronomy and a promising vantage point for future activity with larger antennas.

Earth's vicinity causes similar problems for certain wavelengths of light as well. To overcome these difficulties, astronomers sent a camera to the moon with Apollo 16 in April 1972. The device was used to make extreme ultraviolet (XUV) surveys of Earth, stars and galaxies, and determine the usefulness of lunar observatories.

The wavelengths of interest cannot be observed from near Earth because of radiation emissions by atomic hydrogen in Earth's geocorona. Scientists wanted to view the universe in a far-ultraviolet band, because very hot stars are strong emitters of far-ultraviolet light. Furthermore, atmospheric researchers wanted an overall image of the geocorona and airglow which would be obtained only by looking back at Earth from a great distance.

A wide array of experiments was planned for this first lunar observatory, including the following: determine the composition and structure of Earth's upper atmosphere from measurements taken by the spectrograph attached to the camera; study the geocornoa's structure from measurements in the Lyman-alpha emission band characteristic of hydrogen; study day and night airglow and aurorae; obtain spectra and imagery of inconsistencies (if any) of the solar wind and other gas clouds in the solar system, and interactions with interstellar gas; search for gases in the lunar atmosphere — including possible transient constituents — and interactions with solar wind; obtain spectra and colors of external galaxies in the far-ultraviolet, adding to the knowledge of their composition; obtain spectra and colors of stars, globular clusters, and nebulae within the Milky Way; study interstellar gas, emission nebulae, possible intergalactic gas, and halos of external galaxies and galaxy clusters; evaluate the lunar surface as a site for future astronomical observations with regard to stability, background sky glow, and thermal control.

This sweeping program was made possible by a simple camera spectrograph that hitchhiked to the moon. Taking advantage of the already planned lunar mission, astronomers at the Naval Research Laboratory in Washington, D. C. built and tested the apparatus and included it in the mission planning. Further flights were expected on later Apollo missions, but these launchings were canceled for budgetary reasons.

Future lunar observatories, of course, would have to be far more powerful than this simple survey device. Its field of view was almost 20 degrees, with a pointing accuracy of several degrees and a resolution of only two minutes of arc. But even observations as gross as these were invaluable for astronomers.

Almost 200 photographs were produced over a two day period. (Film was carried back to Earth by Apollo astronauts.) Targets included over 500 stars, nine galaxy groups, six globular clusters and four planetary nebulae. In particular, observations included the North American nebula, the Loop nebula in Cygnus (a 50,000 year old supernova remnant), the Pegasus cluster, the Fornax cluster, and the center of the Milky Way.

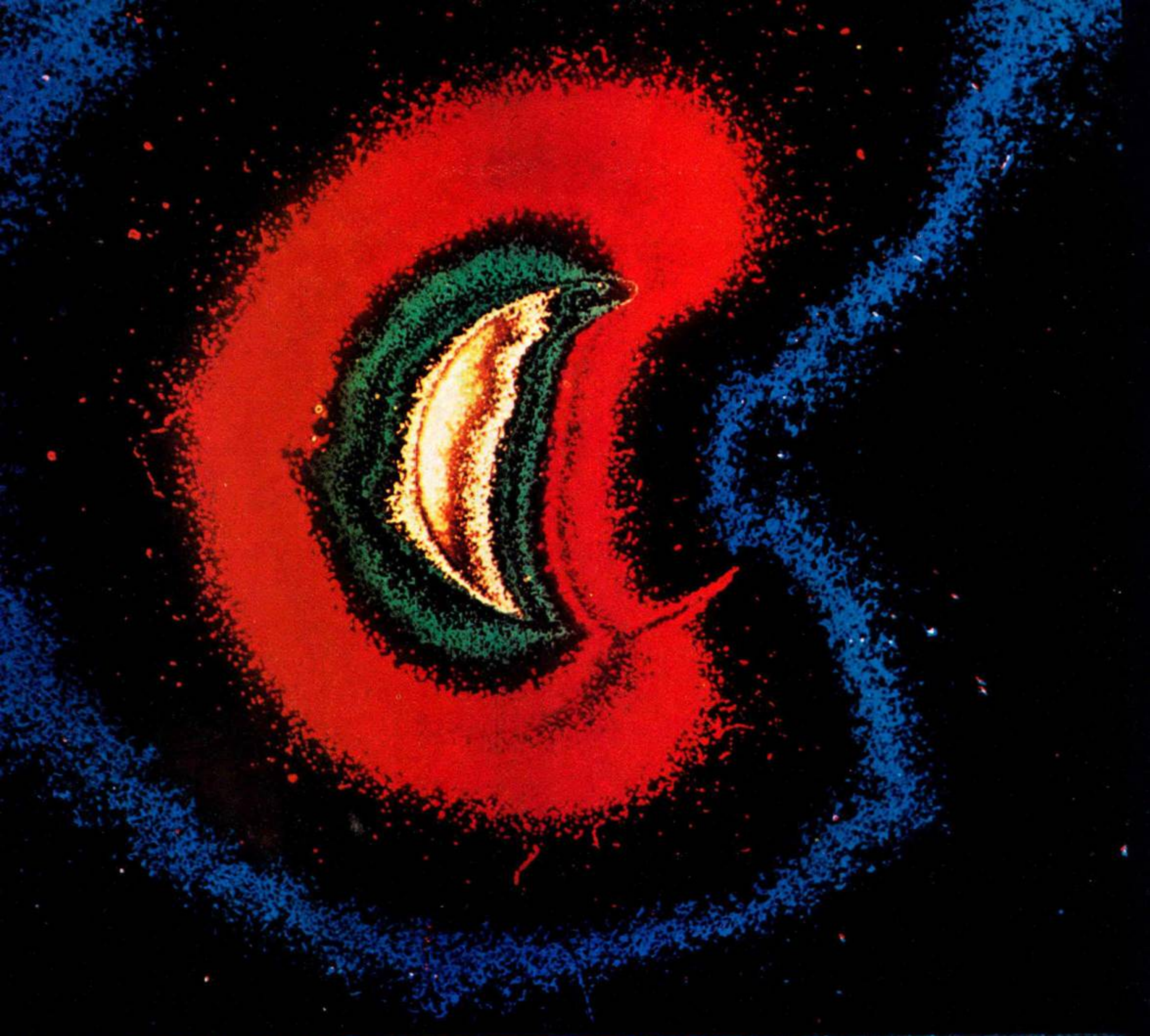
Detailed observations were also made of the Large Magellanic Cloud — the nearest external galaxy. Only very hot stars (12,000 degrees Fahrenheit and hotter) appear on the photographs. Comparison with visible light photos, which show the more numerous cooler stars, gives an idea of temperature distribution (and therefore stars of different evolution or age) in the Milky Way's small satellite galaxy.

The Magellanic Cloud photographs were taken not far from the lunar horizon, and reveal another feature that will be important for future lunar observatories. Although sky background radiation is extremely low even in broad daylight, radiation from atomic hydrogen is present both from interplanetary space and possibly from a tenuous lunar atmosphere (an alternate source of near-horizon haze could have been stray ultraviolet sunlight scattered into the instrument).

From the moon, Earth study is no longer *local geophysics* but a branch of astronomy called *comparative planetology.* A comprehensive view of an entire planetary hemisphere makes it possible to observe related but widely separated phenomena simultaneously and detect possible cause and effect relationships. In this sense, the best view of some terrestrial phenomena can be obtained by looking back from afar.

Studying Earth's geocorona is of great significance since it is tied closely to studies of the ecosphere, which sustains terrestrial life. Many specialists believe the source of geocoronal hydrogen is the disassociation of water vapor by solar ultraviolet radiation in the upper atmosphere. The light hydrogen escapes into the geocorona and ultimately into interplanetary space, while the heavier oxygen can be ionized or converted into ozone which protects lower layers of the atmosphere from the lethal ultraviolet radiation effects on life forms. Many scientists further believe it is this disassociation process

Surrounding Earth to a distance of more than 50,000 miles is the geocorona — a halo of low density atomic hydrogen (represented by the blue band in the upper photograph). Radio emissions from the geocorona block Earth based observation of the universe in the far-ultraviolet band of the spectrum. Since very hot, youthful stars are strong emitters of far-ultraviolet light, a moon based observatory would allow unhampered study. When Apollo 16 visited the moon in 1972, scientists had their first opportunity to study the extent of Earth's geocorona as well as atmospheric airglow. The bottom far-ultraviolet photograph of Earth from the moon shows auroral activity on our planet's night side. In this color-enhanced portrait, the red crescent is the side facing the sun, while the blue bands of aurorae cross near Earth's midnight meridian. NASA photographs.



Sternbach

— not photosynthesis by green plants — that produces most of the present free oxygen in the atmosphere.

It is important to understand more precisely the natural processes upon which terrestrial life depends, especially now — when human activity threatens to alter the natural balance of the atmosphere. This understanding cannot always be obtained solely from Earth or Earth orbital observations. The moon is a convenient site from which to gather urgently needed data from deep space.

With the examples of these two modest lunar astronomical facilities in mind, we can review the arguments for and against lunar astronomy versus Earth orbital astronomy. In what specific areas do the advantages of being on (or near) the moon outweigh the additional costs of getting there (and getting data back)?

First, the moon is a stable platform — so precise pointing of telescopes can be accomplished more easily than from a free-flying unit. Earth orbital stations are perturbed by gravitational and aerodynamic torques, by spacecraft outgassing and crew movement.

Second, the moon can provide longer uninterrupted viewing periods of a specific object without the occultation of half the sky by Earth every 95 minutes. Photographic exposures of up to two weeks (and in polar regions of the moon, practically indefinitely) can be made.

Third, the near-Earth environment interferes with many observable radio and ultraviolet wavelengths. Earth's magnetic field alters the paths of incoming charged particles, and near-Earth radiation levels are high enough to seriously damage onboard films, magnetic tapes and optics over a long period of time.

The moon's horizon can give astronomers a distant and discrete occulting edge. This can be used to determine precise locations of cosmic ray and x-ray sources by noting when the signal ceases (or is occulted), and plotting the horizon curve against the celestial sphere at that instant. In addition, this is a useful technique for studying multiple stars and extrasolar planetary systems at visible wavelengths.

From the moon we can study the universe. But more importantly, from this distant vantage point we can better understand our planet Earth. Our world is a comprehensive unit with many interacting variables that can alter its entire environment. By observing an entire hemisphere with widely separated phenomena at the same time, it is possible to detect and predict global cause and effect relationships. NASA photograph.

Caption for pages 12-13

What will our studies of the universe show from an observatory on the moon where photographic exposures of the sky could last two weeks or more? This imaginary photograph reveals even gas and dust between the stars. The galaxy at the horizon is M-31 in Andromeda. Can you find Cassiopeia, Perseus and other constellations? Here the lunar landscape is well lit and sharply defined by starlight, but in a real photo it would be blurred due to the moon's rotation. Artwork by Rick Sternbach.

Observations could be made from lunar orbit as well as from the lunar surface, but with two drawbacks. First, the angular rate of scan across the sky is 200 times faster from an orbiting detector. This requires very fast photometry to observe objects with very small angular separations (on the order of a few seconds of arc or less). Secondly, from lunar orbit, the exact geometry of the occulting horizon would be indeterminable to within about 10 arc seconds, while the constant horizon of a surface site could be precisely surveyed to any accuracy required.

Lastly, the moon has certain resources possibly useful for astronomical purposes — building material, manpower and equipment from nearby research installations, and the deep cold of the lunar night to chill infrared telescope detectors to near absolute zero temperatures.

On the other hand, lunar observatories have their own drawbacks as well. Not the least of these is the additional cost of getting there, in a phase of contemporary space exploration when there is no available hardware for sending large payloads or manned vehicles there at all. But even if there were no cost differential, certain other negative factors would still exist.

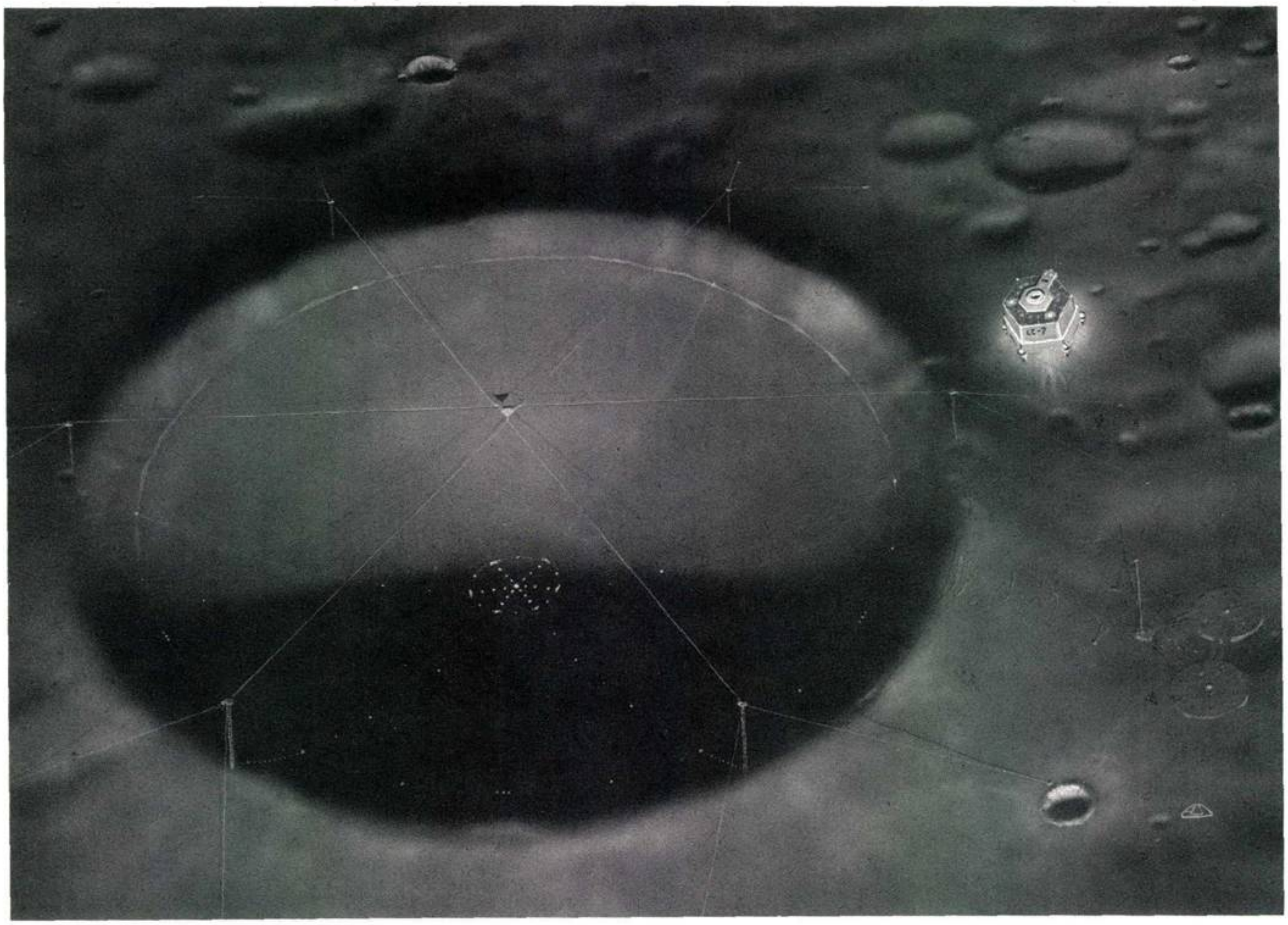
On the moon, observatory equipment and support structures would still be subject to gravitational stresses.

A rarely mentioned factor worth considering is that the moon's rotational motion and orbital path are not as simple as Earth's, since effects of precession (the wobble of the moon on its axis) would require measurable compensations in long exposures and in calibration of observations made at different times. This complicates the mechanical problems of following targets across the sky. Furthermore, smooth pointing accuracy to less than one second of arc would be affected by the tooling of the gear teeth in the tracking mechanisms. Promised accuracies from the "stable" moon may not be technologically feasible.

To support the thousands of pounds of shifting apparatus, the foundation for the equipment must be massive and securely sunk into the lunar surface, since the laws of inertia are still in force on the moon. This foundation must be sent from Earth at a tremendous payload cost, or manufactured on the moon from local materials at a cost in equipment which does not justify use of such a foundation by merely an observatory.

Lastly, the cost of communications, control, and data return (radio or film recovery) must be accounted for in any operational system. The best astronomical locations such as the lunar farside are the worst operational sites from the cost standpoint.

Despite these engineering arguments, optimistic forecasts of huge lunar observatories are still widespread. One vision by astronomy proponents as a justification for returning to the moon is



Proponents of lunar observatories envision mammoth radio telescopes on the moon's farside. While 100 mile wide Arecibo installations are unlikely, smaller radio telescopes five or six miles in diameter are both feasible and potentially useful. Artwork by Adolf Schaller.

a 100 mile wide Arecibo type radio telescope built inside a farside lunar crater. Like the famous terrestrial radio telescope located inside a mountain bowl in Puerto Rico, these lunar radio eyes would be built simply by lining a large crater with metal foil and putting an antenna on a tower in the middle or suspended on cables from the crater rim.

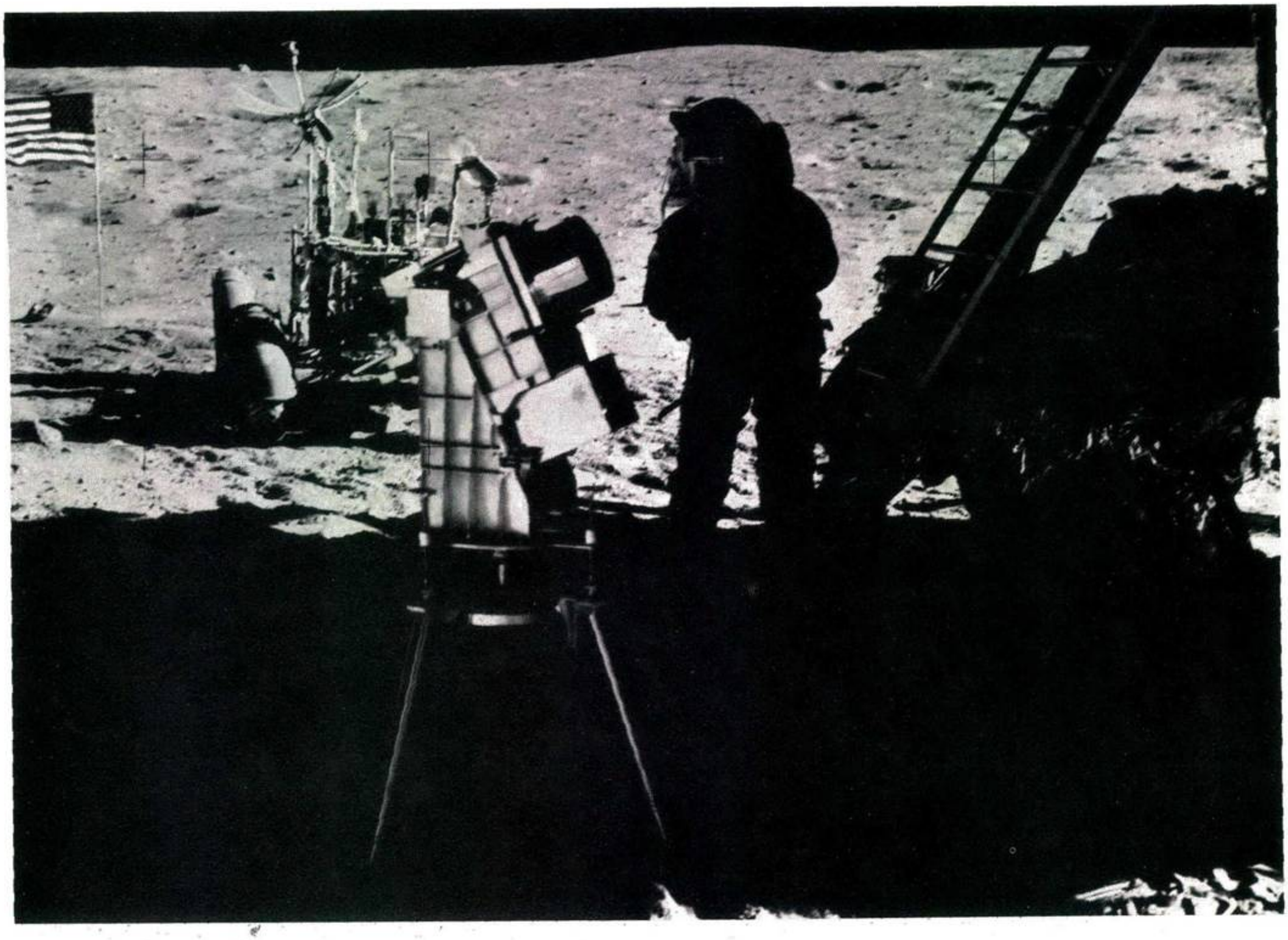
Unfortunately, that plan won't work. The dish must be in the form of a parabola, with the antenna at the focus. Despite the apparent ruggedness of lunar topography, most lunar craters are very shallow. They do not allow a tower or rim-cable mounted antenna to reach anywhere near the required height. A 25 mile wide crater three miles deep would require the antenna feed to be 52 miles high (perhaps the antenna could be on board an orbiting satellite). Even a 10 mile wide crater one mile deep (typical of lunar features) would require a six mile tower in the middle. While smaller dishes a few miles wide are feasible and potentially useful, the mythical giant Arecibo will never be built.

With dreams of a lunar Arecibo shattered, some specialists now call for the construction of radio telescope arrays on the lunar farside. These arrays could be 50 miles wide and 50 miles or more long, with the precise antenna alignment made possible only when they are attached to a large inflexible body (like a planet). A 50 mile long beam in space — no matter how strong — would bend and flex far too much to provide the precision needed for interferometry.

Meanwhile, large space telescopes are also being developed. Pointing and tracking accuracies have been improved by many orders of magnitude with new stabilization devices such as spin gyroscopes and cold gas jets. Certain sky objects can occasionally be observed for long exposures (more than 10 hours, if needed, on a prescheduled basis).

The consensus among astronomers close to the space program indicates that although it might be feasible to establish observatories on the moon, astronomy alone is not a sufficient reason to return to the lunar surface except in certain restricted cases. Astronomy from Earth orbit, however, has an advantage over astronomy from within Earth's atmosphere. All available energies are being devoted to developing orbiting equipment ranging from the Small Astronomy Satellite (SAS) series to the huge Space Shuttle telescopes of the 1980s.

When Americans return to the moon for non-astronomical reasons in the 1990s, these same astronomers will be delighted to take advantage of the moon for unique observations.



Offering stark contrast to scientists' hopes for future observatories on the moon, the above Apollo 16 far-ultraviolet light camera was smaller than astronaut John Young in the background. This "observatory" produced 180 far-ultraviolet photos of the universe. NASA photograph.

The argument about the excessive extra cost of lunar flights versus Earth orbital flights has been repeated often enough to become a cliche. In reality, just how much more expensive would it be to operate on the lunar surface as compared with Earth orbit? Today, both costs are astronomical. By the early 1980s, the Space Shuttle will have reduced the cost of orbital operations tremendously. By the end of that decade, technology will be available to return to the moon with fully reusable vehicles.

At that point, the costs of moon versus Earth orbital astronomy may not be so lopsided. Measured in velocity requirements, the lunar surface is only half again (not five times, or even twice) as far from Earth as is Earth orbit. Measured in developmental and operational costs, the lunar surface may eventually be only two or three times as expensive as Earth orbit operations — still an appreciable factor, of course, but one not out of the question for certain experiments. And since man will be going to the moon for other purposes anyway, the outlook for lunar astronomy brightens again.

Cost factors assume the supplies and equipment for these space observatories must come from Earth's surface; this assumption is so obvious it is almost never stated. But once a self-sustaining lunar or space colony is established (probably by the middle of the next century), all cost comparisons will reverse. It will even be cheaper to supply Earth orbital satellites from the lunar surface than from Earth only a few hundred miles below them. The reason for leaving the space observatories close to Earth will vanish, and the best place for space based astronomy will be the moon.

Gazing into the universe from their lunar observatories of the 21st century, astronomers may be bothered by some things which their predecessors never cared about. Their Earthbound colleagues had to contend with atmospheric distortion, absorption, and airglow. Lights of a thousand cities and the static of a billion electronic devices shouted down the faint signals they sought in the skies.

Undoubtedly the moon will not be perfect for astronomy either, as visionaries a century from now will try to point out. After all, there still is all that interplanetary plasma drowning out radio signals. There is still zodiacal light blocking the view of the planetary systems of some nearby stars. And the solar atmosphere and magnetosphere dominate what might be the fascinating study of galactic particles and fields. What will be needed then is an observatory on Pluto....

STELLAR BEEHIVE

by

David L. Moore

Eighteenth century comet hunter Charles Messier peered closely at the fuzzy and seemingly fixed object in his telescope eyepiece. Obviously, he mused, it was not a comet, and he labeled it M-2 in his list of "objects not worthy of further observation".

Today we recognize Messier's list as a catalog of some of the sky's more spectacular objects — galaxies, nebulae and star clusters. M-2, of course, is an immense globular star cluster — 1 of 28 such objects listed by Frenchman Messier.

More than 115 of these objects are known to exist, and scientists believe many more may lie hidden from our view, obscured by dense clouds of opaque dust and gas in our galaxy.

Tightly packed colossal "balls" made up of perhaps hundreds of thousands of stars, globular star clusters seem to form a spherical halo around our Milky Way galaxy. More concentrated toward the galactic nucleus, they are found both above and below the plane of our galaxy. Astronomers estimate that the axis of their huge halo may measure some 130,000 light-years across.

Scientists describe globular star clusters as dense collections of suns so compact toward their center that it is difficult — and sometimes impossible — to separate their nucleus into individual stars. The sheer number and collective mass of these stars — their mutual gravitational attraction — has held them together since their birth.

Theories for the formation of our galaxy explain that globular star clusters probably formed out of the primordial spherical gas cloud that became our Milky Way in masses large enough to survive the tidal frictions of the collapsing, condensing protogalaxy.

Newly formed globulars then followed elliptical orbits about the Milky Way's core. As they made repeated passes through the galactic plane, they were swept "clean" of star building gas and dust so that today globular star clusters contain only stars and little else.

Using the new 158 inch telescope at the Cerro Tololo Inter-American Observatory high in the Chilean Andes, astronomers are studying 47 Tucanae — one of the brightest globulars known to man — for new insight into star formation.

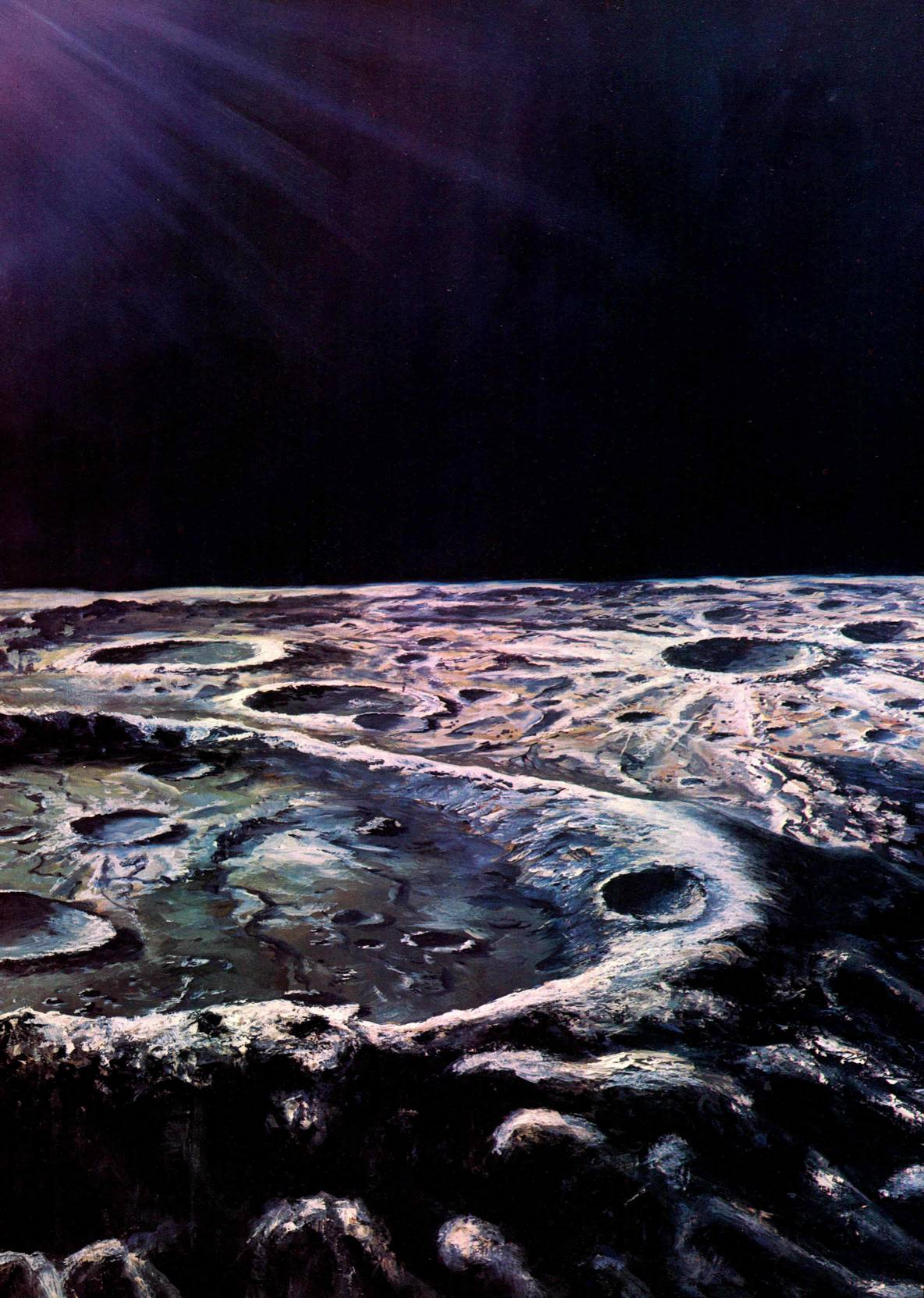
Since globular star clusters are believed to represent the earliest stages in the collapse of the gas cloud that formed our galaxy, objects like 47 Tucanae may contain the last stars formed prior to the Milky Way's birth.

Although 47 Tucanae is visible only in the southern hemisphere, skywatchers north of the equator can observe several fine globulars this winter.

Many may elect to emulate Messier on that long-ago night and observe M-2 in the constellation Aquarius. English astronomer Lord Rosse once described M-2 as having "streams of stars branching out, taking the direction of tangents". Nearby is another bright globular M-15, in the constellation Pegasus.

Imagine what our night sky would look like if our sun were a member of a globular cluster. Instead of the 6,000 or so visible stars we now see, the night sky would literally glow from the light of hundreds of thousands of stars. Many of the nearer ones would rival the full moon in brilliance, while most of the faintest stars would be visible to the unaided eye.

The dark, sometimes forbidding night sky — as we know it — would cease to exist. In its place, the landscape would literally be awash with starlight. ◆



THE PLANET MERCURY

by Eric Burgess

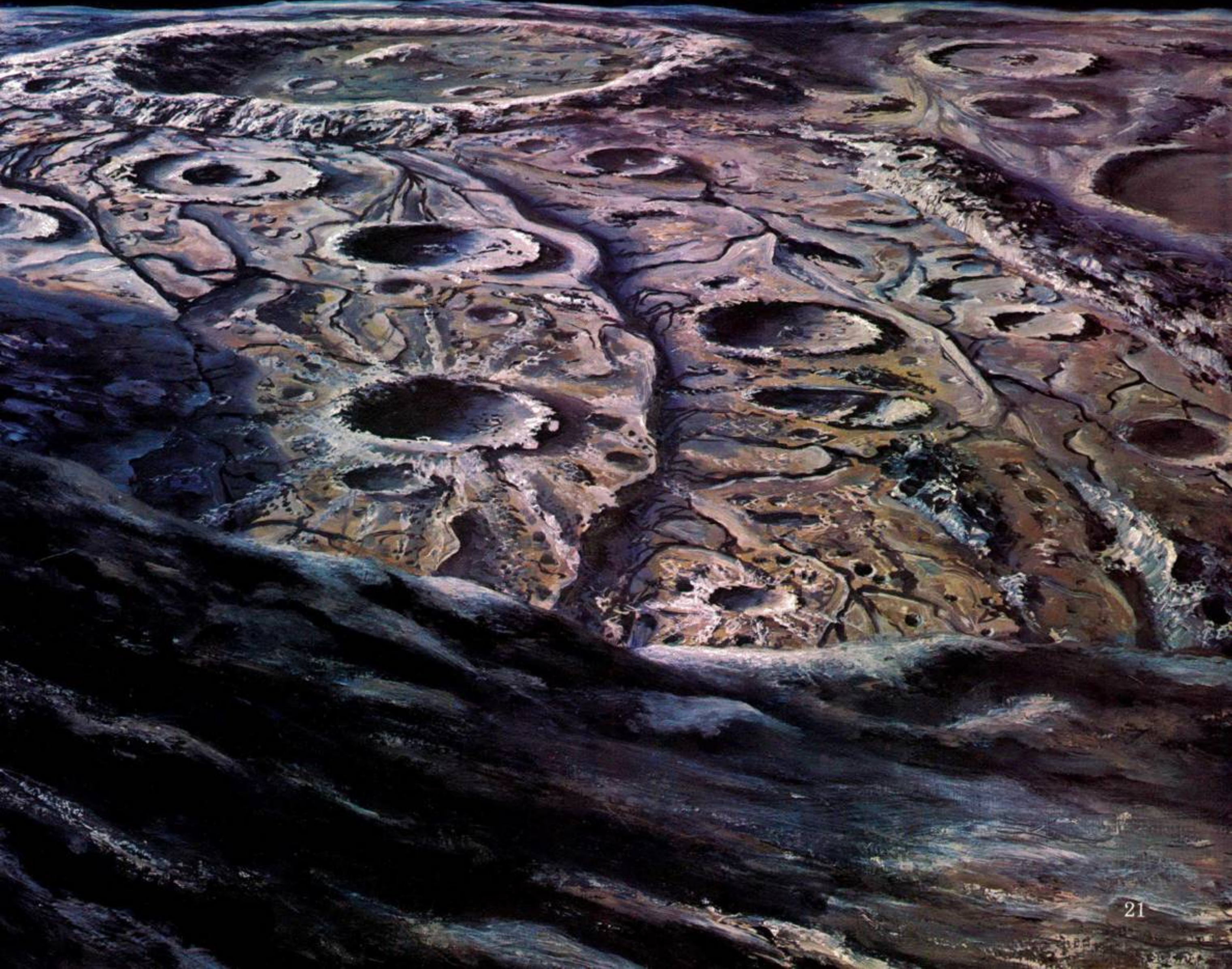
Not much larger than Earth's moon, Mercury races around the sun like a moth about a flame — so closely that it is extremely difficult to observe.

In fact, until the space age, little was known about the innermost planet — a world so obscure that few astronomers had ever even observed it.

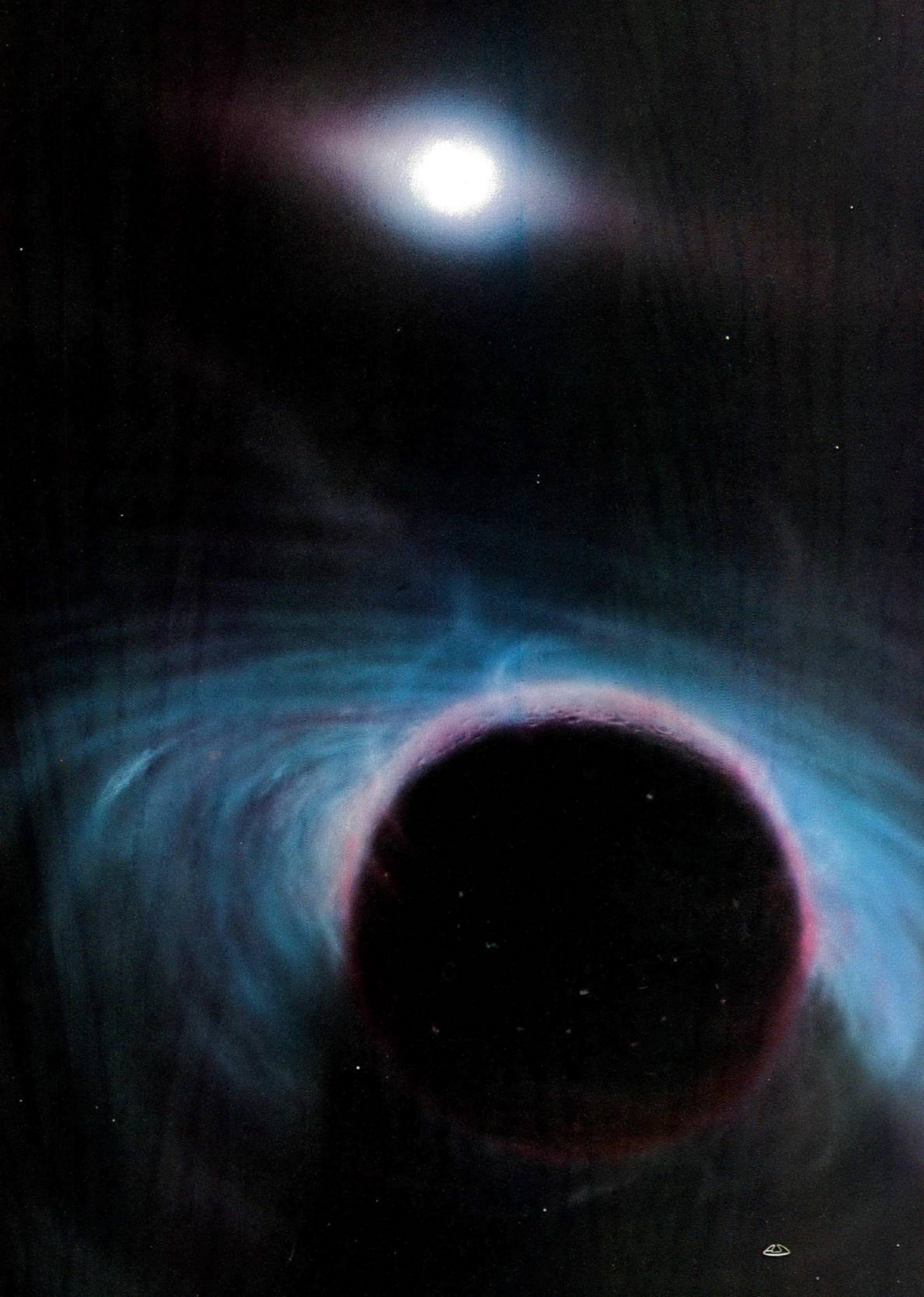
The mission of Mariner 10 changed all that. From cameras and instrumentation mounted on a spidery spacecraft coursing a hundred million miles away came images of a "new" world. Here were giant scarps that snaked through craters, highland areas filled with both old and new craters, and lowland areas made up of large volcanic plains.

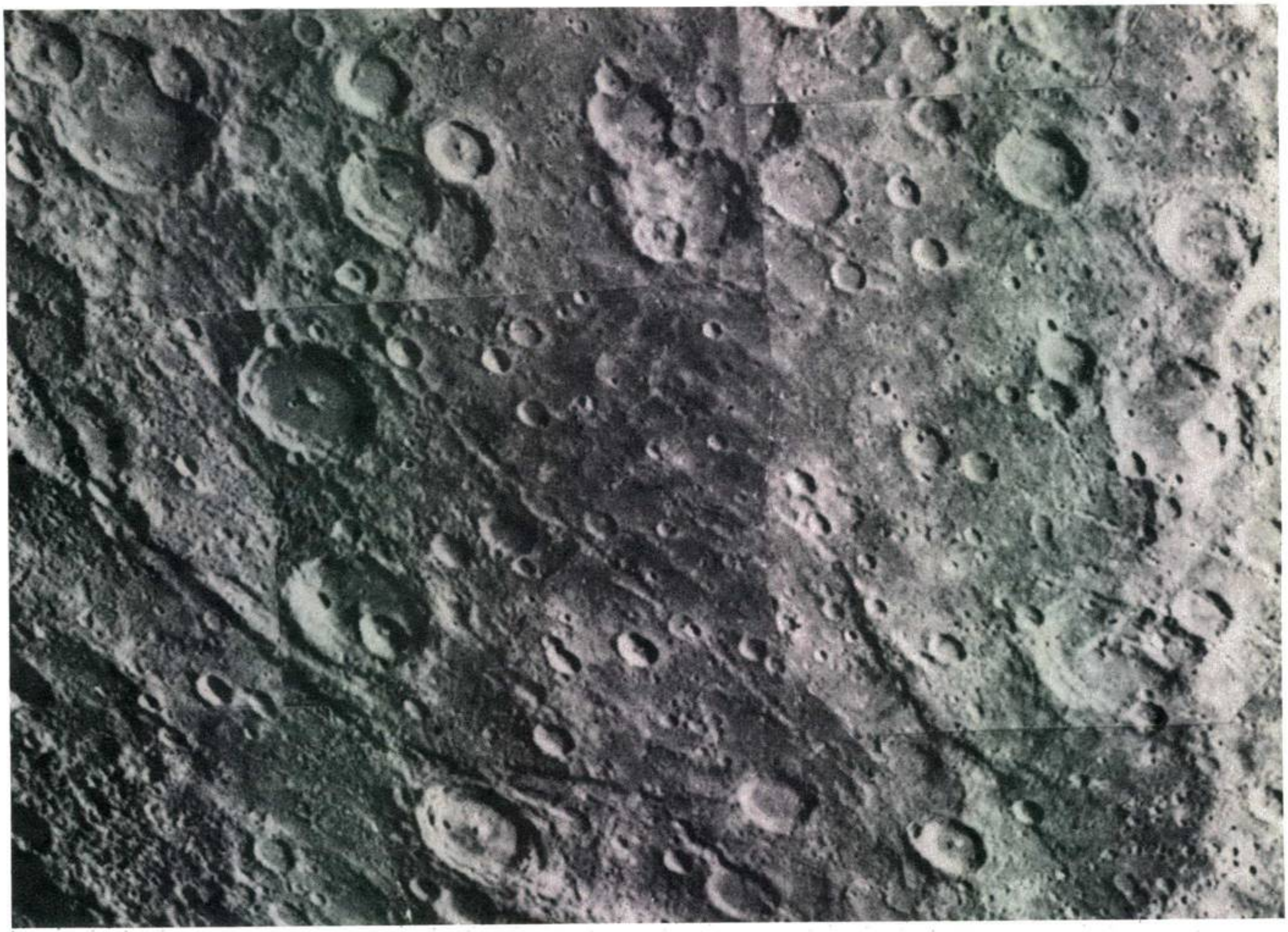
Its surface moonlike and its interior dense and Earthlike, Mercury's features showed no signs of erosion from water or wind. Mercury has no blanket of atmosphere but it does have a strong magnetic field. According to current theory, Mercury would have to have a liquid core with strong convection currents — an internal dynamo — for so strong a magnetic field to exist. And yet there seems to be little evidence that can account for a liquid core.

Today, questions being asked about Mercury and its history are remarkably similar to those asked about the moon prior to the space age. Was the surface molded by volcanism or by impacts — or both? In what sequence did the formation of the surface features occur? In addition, can the time scale of lunar geology learned from Apollo be applied to the surface evolution of other planets? Were events that molded the surface of the moon common to all terrestrial planets of the solar system? Without direct evidence from Mars or Mercury, scientists cannot be sure that all the planets formed at the same time and were subjected to similar episodes of surface molding in the form of bombardments and vol-



From the rugged floor of Caloris Basin — Mercury's single largest feature — future explorers might find it difficult to comprehend the world-jarring cataclysm that created this 800 mile wide blemish. An inhospitable world blasted by the glaring brilliance of the nearby sun, it probably would be impossible to see stars in Mercury's airless sky. Artwork by John Clark.





When Mariner 10 flew past Mercury for the second time, it photographed the planet's heavily cratered south polar region. Revealed here are numerous scarps — towering cliffs that scientists believe represent "wrinkles" that formed as the planet cooled and shrank. NASA photograph.

canism. Some current theories suggest that Mercury may have formed earlier than other terrestrial planets, and Mars much later — as much as several billion years later.

Origin of Mercury

To assess the new information about Mercury, and how it fits into present theories of cosmogony, planetologists are evolving theories about its formation from the solar nebula, interior evolution, and molding of its surface.

Perhaps in the zone where Mercury formed, two processes starved the planet of material and caused its small size. Material falling into the developing sun may have kept Mercury small. On the other hand, outflowing energy from the young sun might sweep the inner solar system of much of its gas and fine debris — material that planets are made of.

Two theories developed concerning Mercury's birth from the solar nebula even before the voyage of Mariner 10. In the first model, as the primordial solar nebula cooled, the inner ring of dust and gas remained essentially in balance. Within a few billion years, the innermost planet condensed from a homogeneous mix of iron and silicates with iron predominating.

Following accretion from the primordial solar nebula, the planet Mercury may have been subjected to heavy bombardment from chunks of space debris. This — combined with global volcanism — created a molten surface. Artwork by Adolf Schaller.

Once formed, uranium and thorium within the planet continued to decay radioactively, heating the interior until the iron and silicates melted. At this point, iron sank toward the core, and the silicates rose toward the surface. Convection carried heat from Mercury's interior to its surface where it was radiated into space. The *equilibrium condensation model,* as this theory of Mercury's formation is called, says the interior of the planet cooled within a few hundred million years and solidified causing the planet to shrink slightly in radius — just enough to account for the unique compressive scarps found by Mariner. Since these sinuous scarps deform old craters but are broken by younger ones, core shrinkage must have occurred as the bombardment of the surface eased billions of years ago. But this doesn't explain the strong magnetic field recorded by Mariner 10 which would require Mercury to have a molten core.

The second theory of Mercury's formation — the *inhomogeneous accretion model* — says that solids formed into planets faster than they condensed

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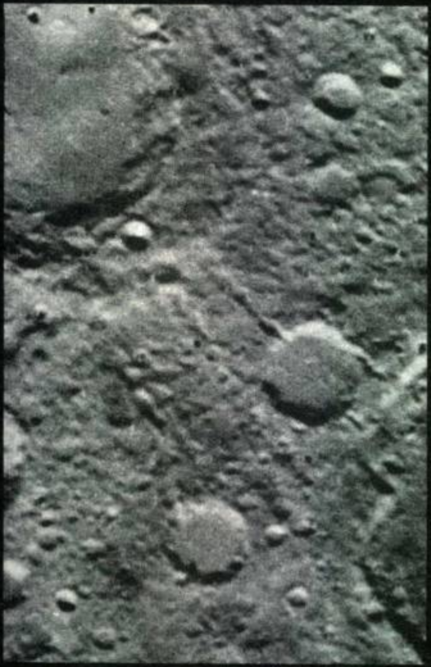
Mercury's Surface Features

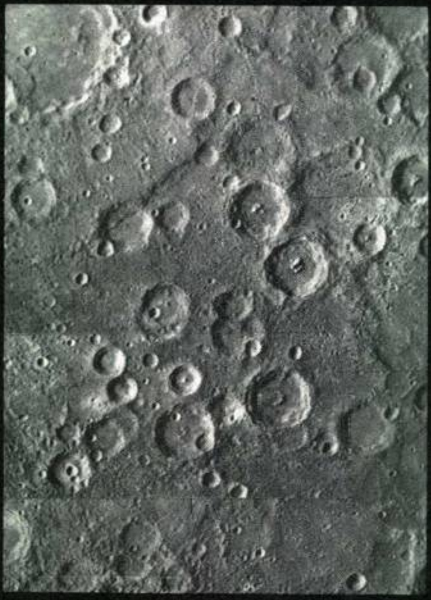
Mercury's surface is not impacted with evidence of erosion by further bombardments. Rather, it gives the impression of an episodic history: accretion ending, surface smoothing, final bombardment. Early in its history, Mercury could have had volcanism and an atmosphere which was lost later — even before the final bombardment. Earth based observations at thermal, infrared, and radio wavelengths suggest that the surface is rougher on a small scale than the moon, and regolith — although similar to the moon — is thicker.

Arranged in approximate order of age, surface features of Mercury can be classified into eight broad geological units — intercrater plains, heavily cratered terrain, young craters, Caloris basin, weird terrain, smooth plains, scarps, and bright rayed craters. While these features follow generally from oldest to youngest, some do overlap on the time scale or cannot be clearly placed in sequence. In general, we see a heavy rain of secondary craters on Mercury. The smallest are typically bombcrater shaped while larger ones exhibit slumping, terracing and central peaks. The largest craters show multiple peaks, and the very largest have an inner ring about 1/2 the diameter of the crater's outer rim.

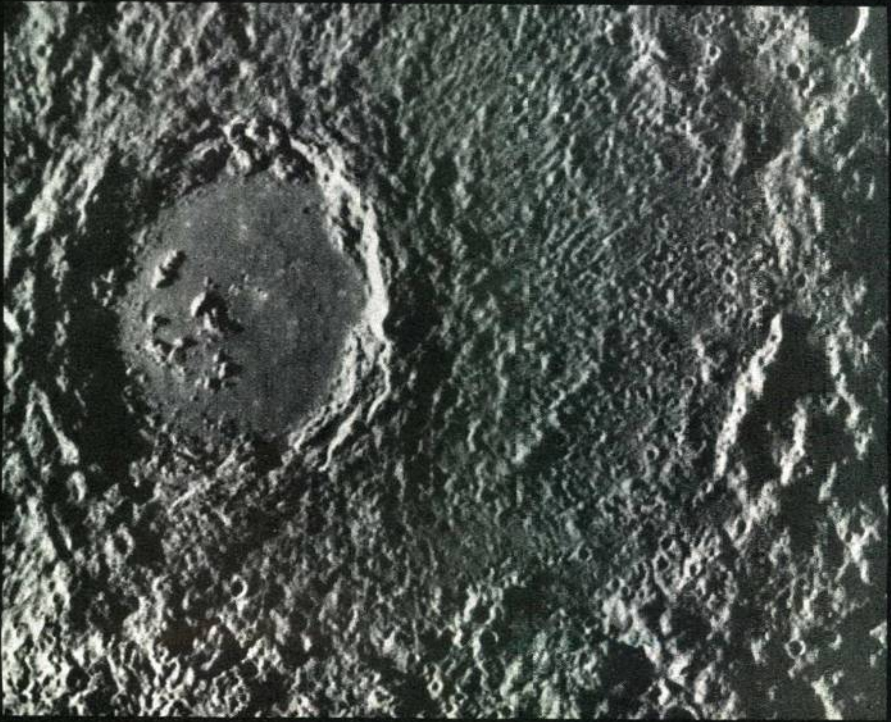
Intercrater plains appear to be the most ancient features on Mercury's surface. Heavily pockmarked with many small secondary craters, this gently rolling landscape stretches between large craters and impact basins, offering stark contrast to the smooth floored younger craters. Intercrater plains seem to be the "field" against which other features formed, and are thus probably the oldest features on the planet.

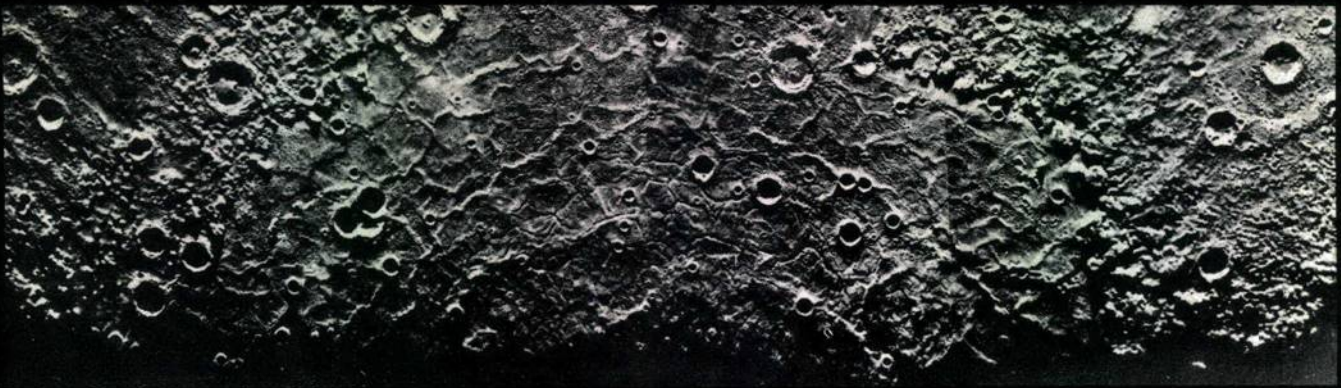


Young craters — formed during a "recent" period of bombardment — are clearly surrounded by blankets of material ejected from the craters following impact. Larger craters display central peaks or groups of peaks, terraced walls and no ray systems. Accordingly, they are believed to be younger than those of the heavily cratered terrain.

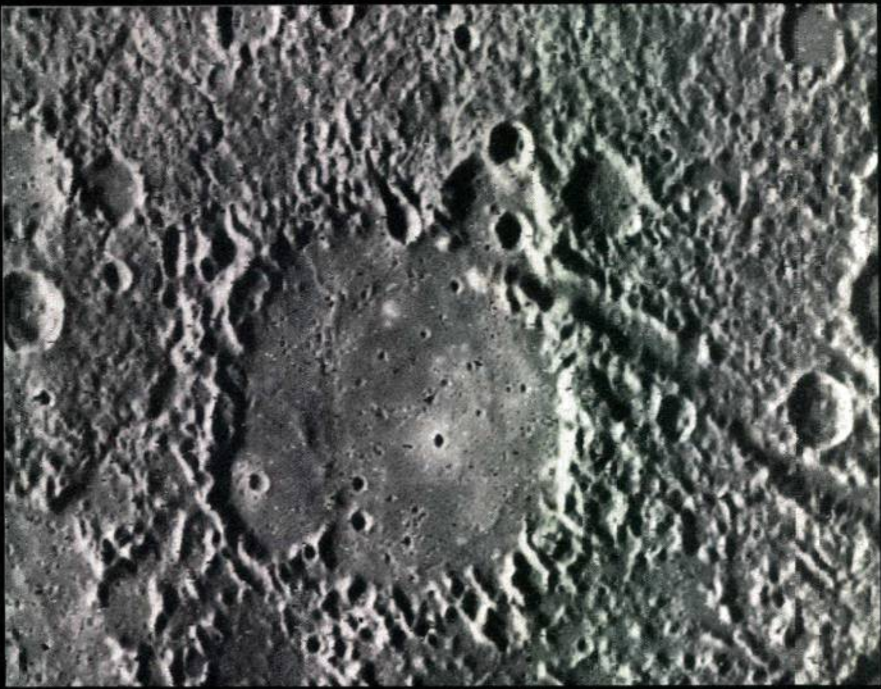


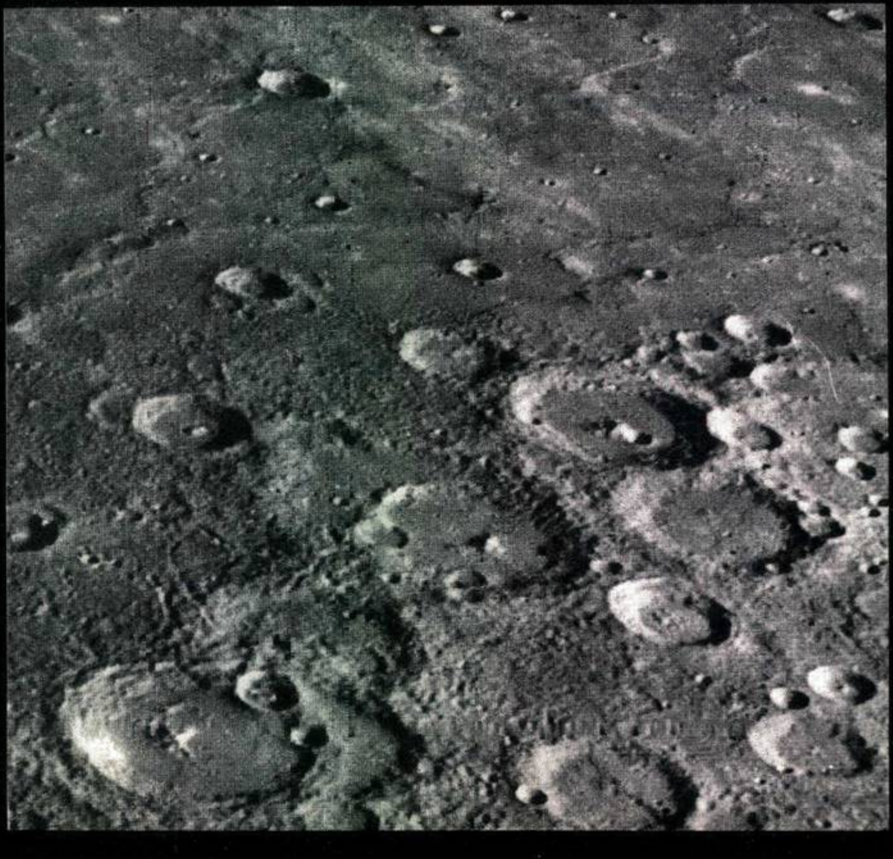
Heavily cratered terrain contains craters in quantities and sizes that are remarkably similar to the lunar highlands. As on the moon, some craters are isolated while others overlap in groups. Ejecta blankets and secondary craters are not easily identifiable. Possibly the secondary craters on Mercury's intercrater plains originated at the same time these heavily cratered regions were formed. Many crater floors in these regions contain material from the surrounding intercrater plains. However, fewer secondary impact craters on these floors than on the plains leads to the conclusion that the floors are younger than both the craters themselves and the surrounding field of intercrater plains.





Caloris Basin is not the oldest impact basin on Mercury, but it certainly is the planet's single largest feature. (Older impact basins are completely degraded.) Young craters on this huge basin indicate that it may have formed after young crater bombardment had begun, but before the bombardment's end in which the most recent of the young craters was formed. This feature, then, represents a time scale overlap with young crater formation which followed creation of heavily cratered terrain. After formation of the Caloris Basin, its floor filled with material that later fractured in a complex ridge and crack pattern. Because the basin is so big and domed — it follows Mercury's curved surface — the ridges were probably caused by downward collapse of the floor, with the cracks forming later as a result of uplift.

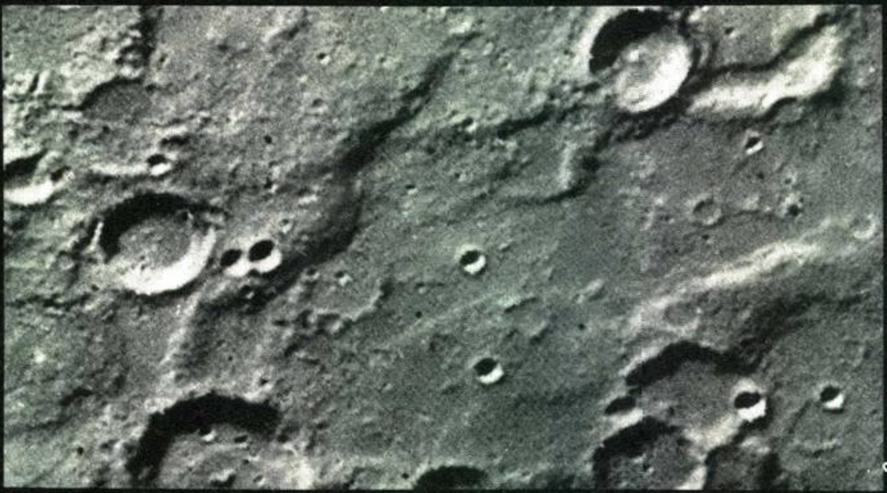




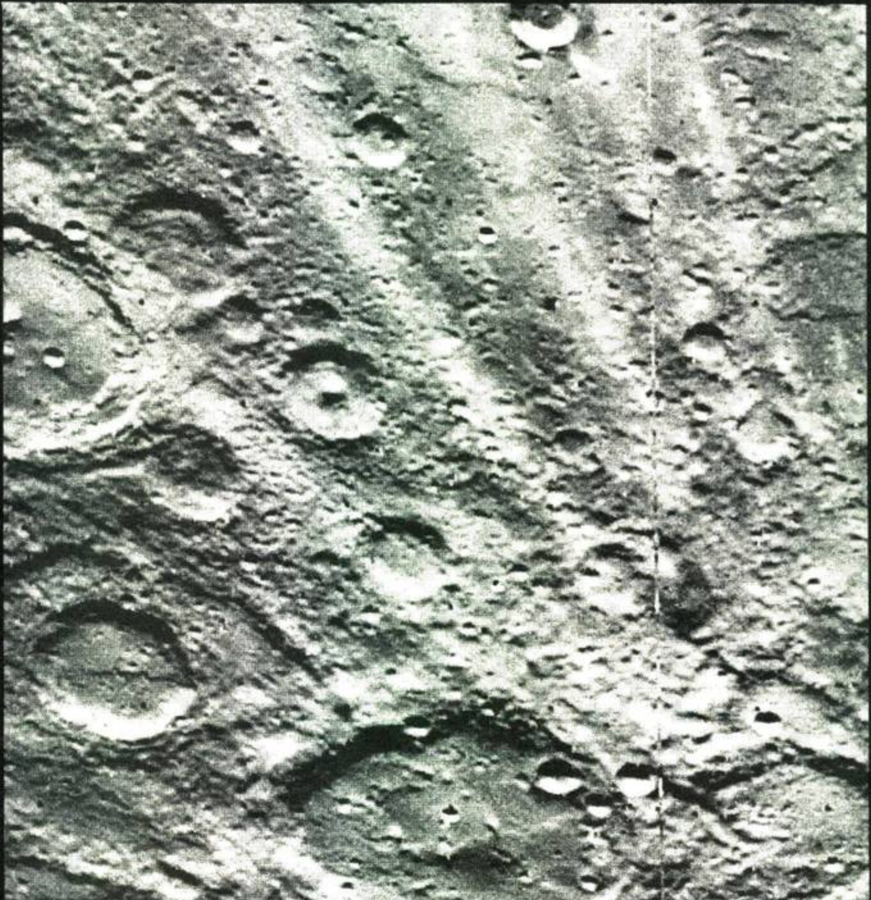
Weird Terrain. The cataclysmic impact that gave birth to the Caloris Basin was responsible for widespread effects on Mercury's surface features. Following the impact, the planet's iron core focused seismic action on Mercury's farside like a planetary lens. At this point — antipodal to the Caloris Basin — is an area of weird terrain consisting of jumbled blocks, broken craters and mountains that seem to have been literally "shaken apart" by the tremendous blast. In age, this region is contemporary with formation of Caloris itself, and simultaneously dates younger crater bombardment.

Smooth plains have fewer secondary craters per unit area than the ancient intercrater plains. They appear to be lava flow fronts resulting from late epoch volcanism that flooded both impact basins and heavily cratered terrain. At the same time, volcanic activity created a smooth new "field" over intercrater plains. The extensiveness of Mercury's plains suggests it has a basically silicate crust.

Scarps — giant sinuous cliffs that traverse the surface for hundreds of miles — abound across Mercury's face. They cut through all features previously mentioned, though on occasion may be interrupted (degraded) by a young crater. Nevertheless, scarps are believed to be younger features than smooth plains since they cut their way through these as well. Rising to a height of two miles, these "surface wrinkles" probably formed as a result of compressive strain in Mercury's outer layers as its iron core cooled causing the planet to shrink in size.



Bright, *rayed craters* are the youngest features on Mercury. They are sharply defined, obviously fresh and have ray systems that extend enormous distances over the planet's surface. Some are surrounded by dark halo ejecta blankets like Tycho on the moon, and have filled floors with sharp central peaks.



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from the gas in the primordial solar nebula. First one substance, and then another, condensed into solids — sequentially accreting into planets with layered shells of different materials. Thus, Mercury began with an iron core and its silicate outer shell was added later. As a consequence the planet did not expand during core formation. Instead, heating expansion occurred as uranium and thorium heated the protoplanet, floating its crust over the core. The core solidified relatively quickly and was perhaps responsible for the scarps.

Plaguing questions still remain: How can Mercury have a magnetic field when the core has long since cooled and is no longer molten? And what is the planet's chemical composition?

If uranium and thorium were abundant at the beginning, it's unlikely Mercury could heat to a temperature that would melt iron and form a core. Suppose the initial core of the second Mercury model began at a temperature of 940 degrees Fahrenheit and was further heated by other radioactive elements. A core would form within 1.2 billion years — but it would cool only 1.8 billion years later. Thus, if internal heating came from uranium and thorium as some scientists believe, Mercury's core would not be molten today.

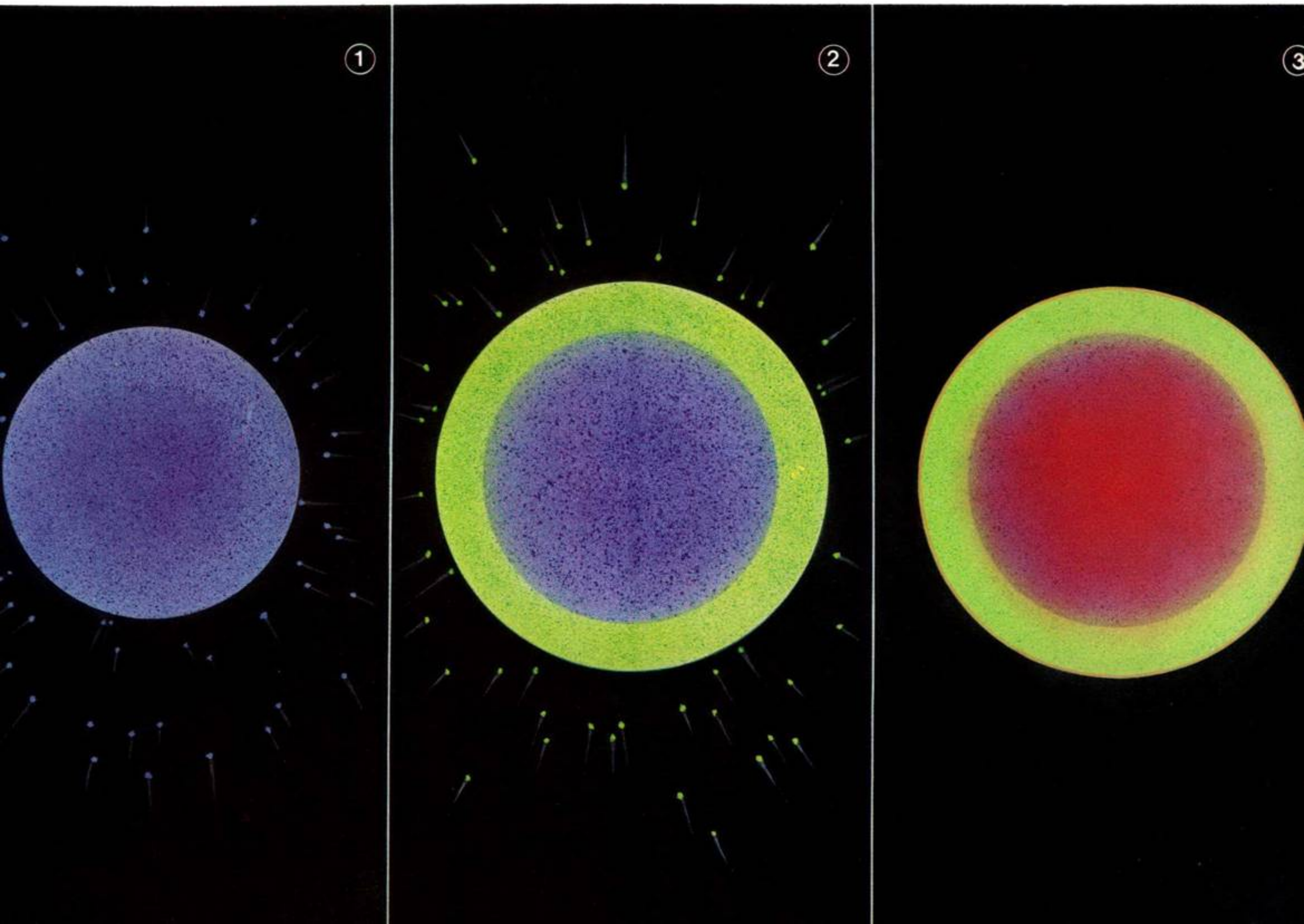
Another possibility exists.

Suppose the formation of a core took place gradually over a long period of time. Mercury's outer shell heated quickly after its formation, but this heat releasing process moved very slowly deep into the planet's interior. It might take 3.5 billion years for Mercury's core and mantle to differentiate and could explain why it still seems to have a molten core today. Surface features such as scarps, however, became difficult to explain on the basis of this theory.

The effects of core convection can sometimes be seen in the planet's shape or surface features. The moon suggests convection from a small hot core with its Earth-facing bulge. Similarly, the "Grand Canyon" found on Mars may be evidence of convective upwelling from a hot core.

Mercury, as well, provides evidence of convection in the form of two bulges where the planet faces the sun on its perihelion passes.

If Mercury exhibits an altered shape as the direct result of past — and current — internal convection, from where does it derive its heat? Possible answers to this enigma include the solar neutron flux which is much more intense at Mercury's solar proximity than at Earth's; tidal flexing,



The inhomogeneous model of Mercury's formation assumes that (1) iron condensed from the primordial solar nebula to form the planet's core 4.5 billion years ago. A half billion years later (2), the silicate outer shell accreted, finally (3) floating its crust. This model does not explain Mercury's powerful magnetic field, however. Artwork by Victor Costanzo.

and orbital flexing. All, however, are highly speculative and difficult to prove with our limited data.

As we have seen, surface evidence suggests that Mercury's core must have formed very early in its history. To form core and mantle, and float a crust that develops enough strength to retain evidence of accretial bombardment implies that the formation of planetary bodies in our solar system obeyed yet-unknown, time-dependent rules.

If lunar age-dating can be applied to Mercury, such evidence also means the planet's surface must have floated — and then solidified — more than four million years ago. The interior must have solidified at an even earlier date.

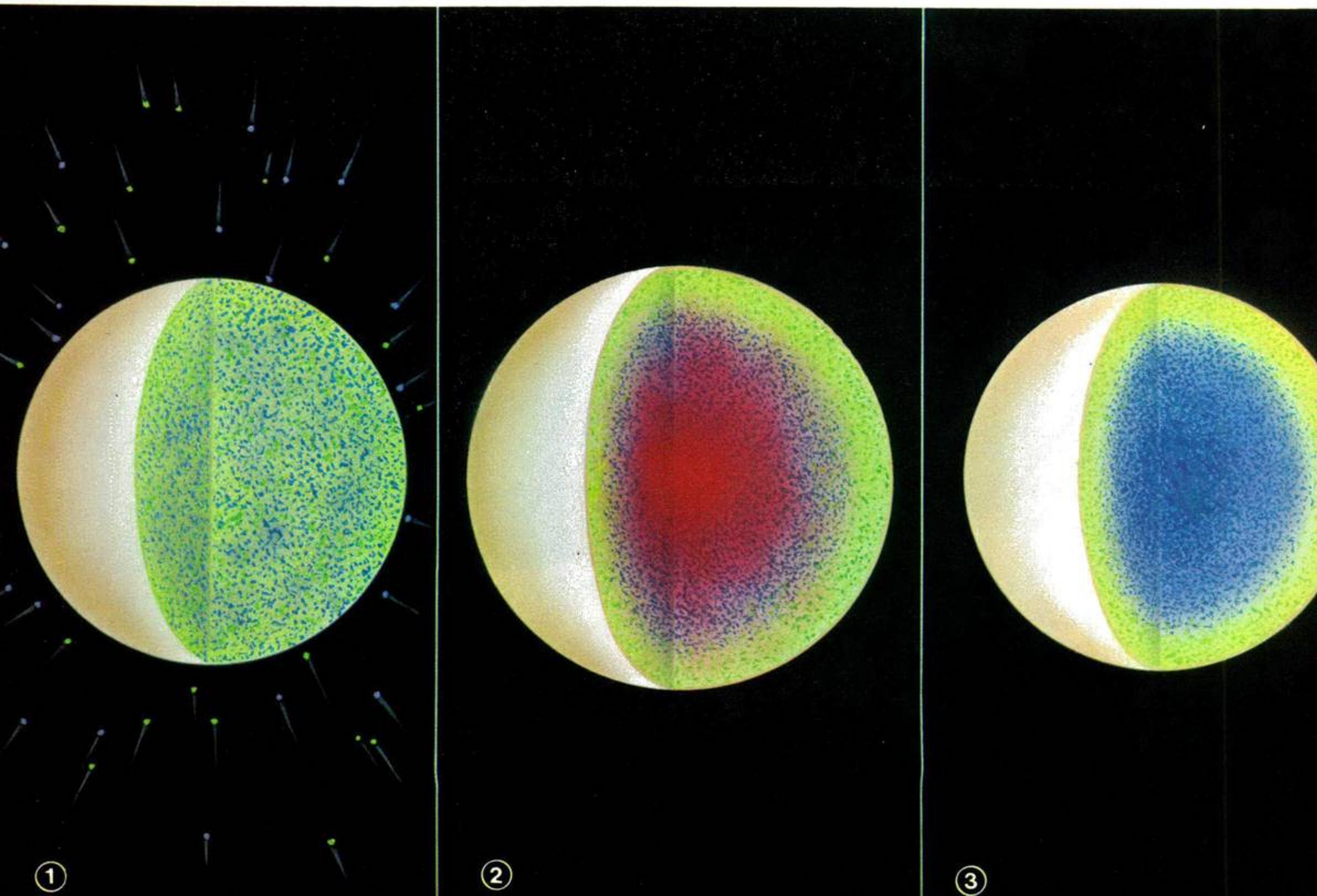
If interior differentation occurred later, however, the surface of the planet would have had to melt near the end of accretion. Some planetologists see Mercury's intercrater plains as evidence of this melting. The later episodic bombardment that saturated our moon did not pockmark this ancient smoothed surface because of Mercury's greater gravity which restricted the spread of ejecta blankets and secondary crater fields.

Mercury's intercrater plains may indeed be evidence of early surface melting. But if this is true, the planet's internal heat would have been rapidly dissipated from the core.

Knowledge of Mercury's molten core is based on Mariner's observations of the planet's interaction with the solar wind, and the measurements of a magnetic field. During the first Mariner encounter, scientists were surprised to find that the planet interacts with the solar wind — much the same as Earth does. They discerned the planet has a magnetosphere and a bow shock wave, both of which seem to be a scaled-down version of Earth's. It was the third Mariner encounter that provided conclusive evidence for Mercury's molten core, and spacecraft observations corresponded with predictions made from earlier encounters.

New discoveries about Mercury — a magnetic field, interaction with the solar wind, a molten core — may make major revisions necessary in the

Below, the equilibrium condensation model of Mercury's origin says the planet (1) accreted homogeneously from materials present in the zone of the primordial solar nebula. After accretion (2), uranium and thorium heated the planet to a molten state so iron could sink to the core while silicates rose upward to float a surface crust. During this period of molten differentiation, the planet's radius increased. Afterward (3), convection cooled the core; the planet solidified and its size decreased slightly. The tail end of accretional bombardment modified the crust, with later cataclysmic bombardment producing present impact basins and most of the existing craters. On the opposite page a more complex model of the planet's formation explains Mercury's powerful magnetic field as well as today's surface features. A wave of heating (1) started in the outer shells, gradually moving inward (2) to differentiate the core over a long period of time. This would allow Mercury's core (3) to be liquid today. Artwork by Victor Costanzo.



current theories concerning planetary dynamos and planetary fields in general.

Mercury's Surface Molding

Two schools of thought clash on the molding of Mercury's surface. Did its surface form by impact molding and melting or impact molding followed by extensive volcanism? Applying lunar age-dating methods to Mercury suggests to many planetologists an episodic surface molding in all terrestrial planets.

According to theory, accretion tapered naturally during the final phases of planetary formation. Planets heated, differentiated and floated crusts, and crusts solidified before the end of accretion. Final impacts before accretion ended made the oldest degraded craters and basins seen today.

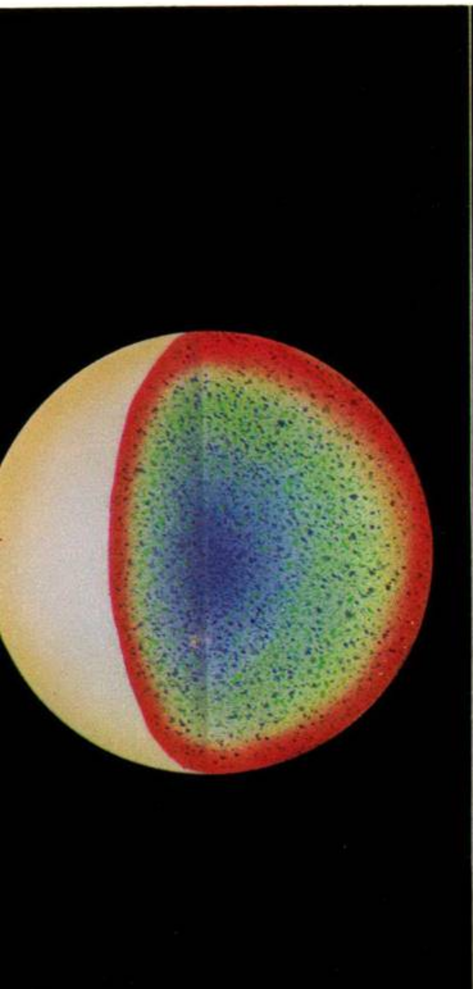
What followed was a period of surface smoothing. Whether smoothing was an effect of further heating or of atmospheric weathering is not yet known. But on Mercury, the vast intercrater plains appear to be a surface smoothed from an earlier roughness. After this smoothing period, another age of bombardment followed which produced heavily cratered terrain. On Mercury, however, this terrain is not as common as that found on the moon. Major impact basins such as Caloris may have been formed during this period or slightly afterward. The material for this second catalclysmic bombardment was either "lurking" somewhere in the solar system, or may have originated from an unknown catastrophe such as the loss of a moon from one of the other inner planets.

Next came a period of volcanism in which crater floors filled with lava and smooth plains formed. As volcanism ended, the planet became stable and was subject to fewer and fewer bombardments creating the fresh rayed craters.

Some astronomers contend that the plains of Mercury do not resemble lunar maria — as they have few volcanic features. Others suggest this apparent absence only results from the fact that we have not yet studied Mercury's plains in detail. Even on the moon, volcanic features required a great deal of searching with high resolution cameras of the type not yet used to study Mercury.

Mercury's lightly-colored bays may not actually be volcanic in origin. Instead, they may have been formed as impact melts, a by-product of the energy from bodies blasting the craters. Generally speaking, these materials — both inside and outside craters — are difficult to explain unless related directly to volcanism.

Other mysteries exist concerning the surface features of the innermost planet: Relatively few large craters in the range of 12 to 37 miles have been found. Although there are subdued and eroded craters on Mercury, a complete spectrum of degrada-



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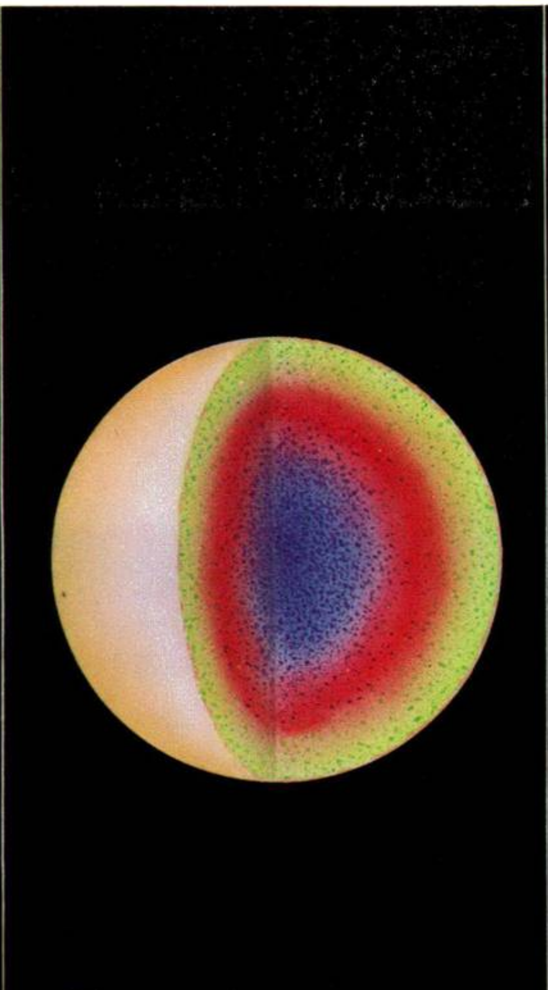

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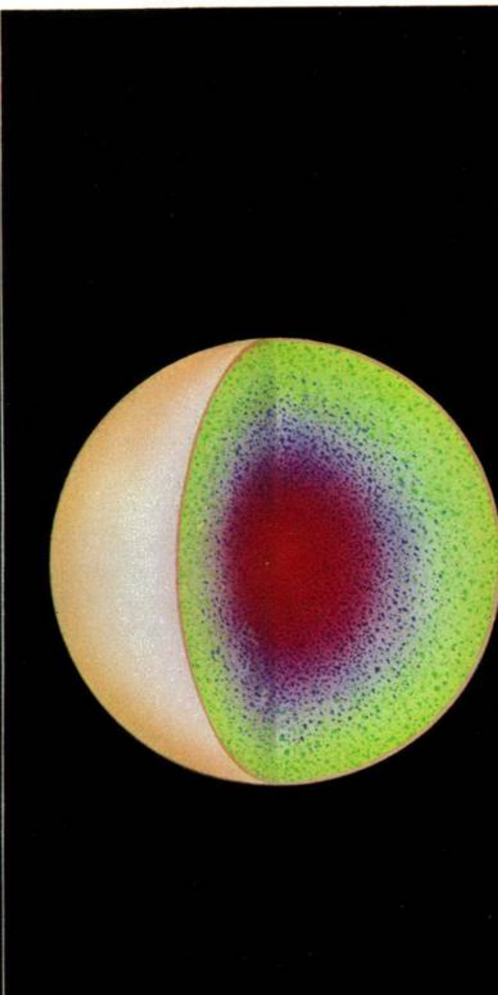

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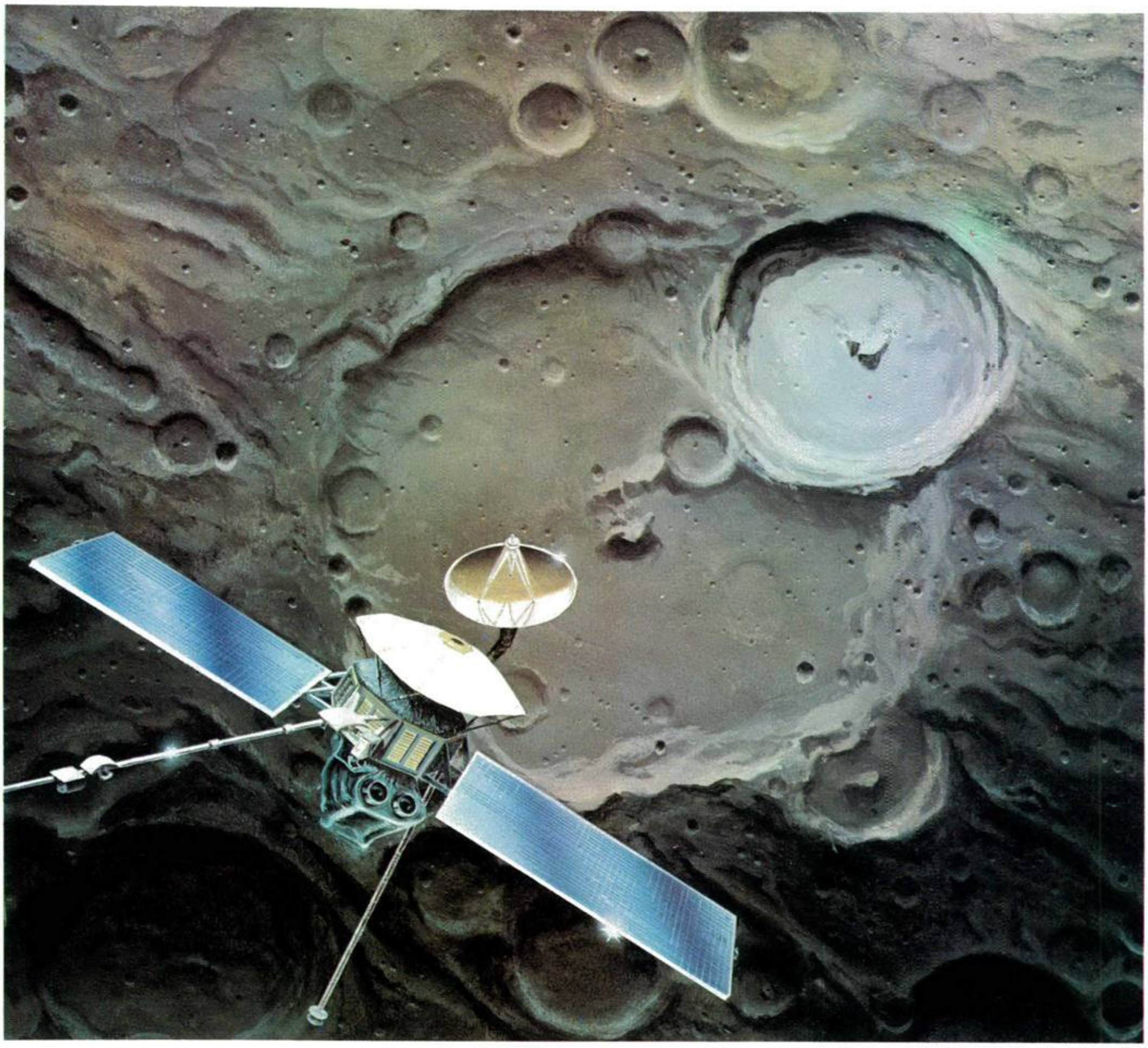

One of the brightest, most conspicuous surface features of Mercury revealed by Mariner 10 is Kuiper Crater (upper right in picture). This fresh young crater — 25 miles in diameter — probably formed during later bombardment of the planet since it has broken the rim of a larger, degraded crater in one of Mercury's intercrater plains. Now knowing where to look, scientists can view this bright crater with Earth based telescopes. Artwork by Victor Costanzo.

tion — such as on the moon — is absent. Yet strange gradation effects are apparent. On the moon, secondary craters disappear first and the ejecta blankets last. On Mercury, the ejecta blankets become degraded while the secondary craters remain.

The surface of Mercury does not seem to represent an impact equilibrium surface such as found on the moon. Instead of an impacted surface further eroded by still more impacts, Mercury shows an episodic history on its face — first, accretion ending; then surface smoothing, and finally bombardment.

The thermal history of the moon, Mercury and Mars seems to be similar. However, the planets remain very different internally. Likewise, Mercury appears to have intercrater plains similar to Mars, but actual craters like those seen on the moon.

Thus the planets might have all formed at different times, at different rates, with dissimilar compositions and sizes, and contrasting thermal and geological evolution.

Whatever the eventual solution to this evolutionary puzzle may be, Mariner's exploration of the scarred and scorched cinder called Mercury has brought us leaps and bounds forward in our knowledge and understanding of the solar system.

In the words of California Institute of Technology Professor Bruce C. Murray, chief of the Mariner 10 television team, "We have viewed a new world. Mariner's long reach across space has magnified our view of Mercury's surface 5,000 fold, and transported us back in time to the very formation of the terrestrial planets. Further exploration of Mercury can sharpen and expand that view of the past — our past."

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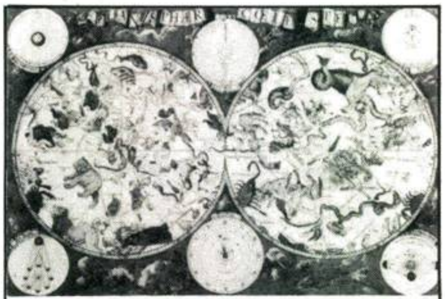

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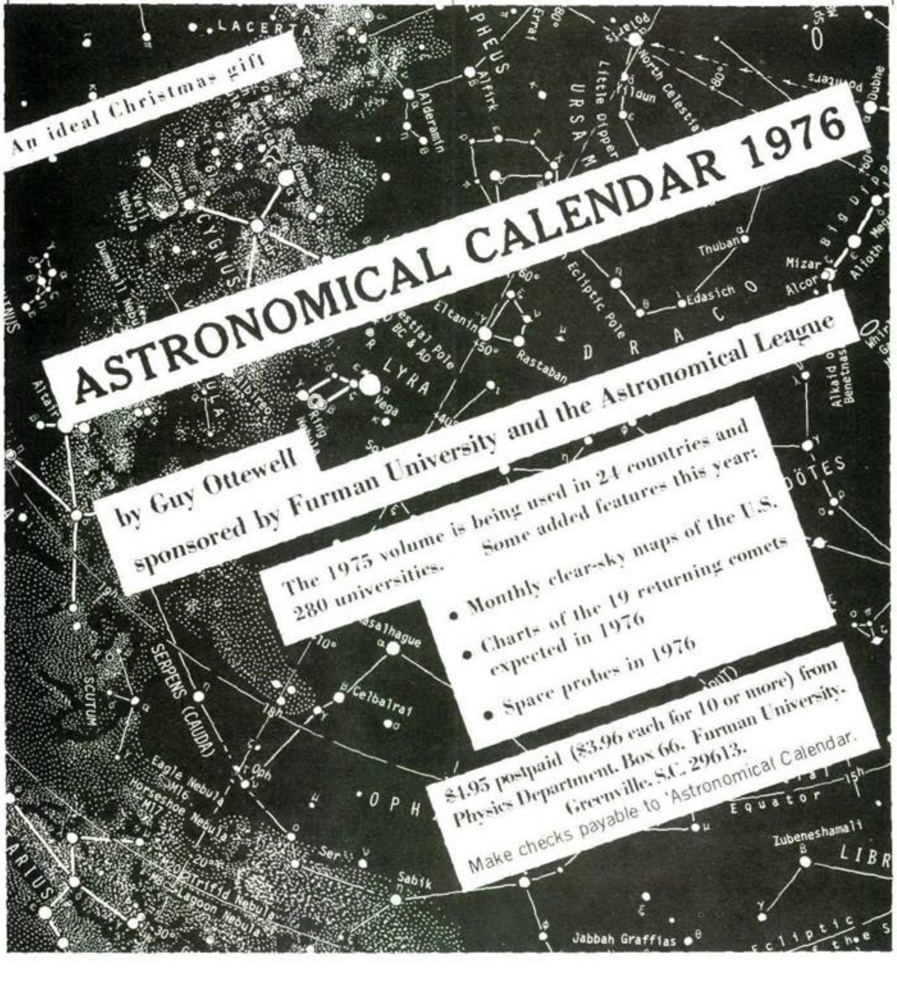
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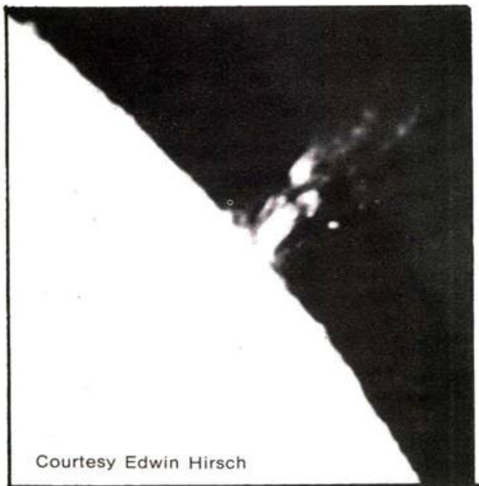
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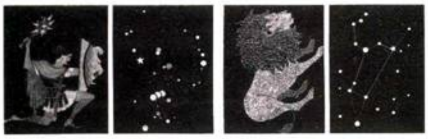

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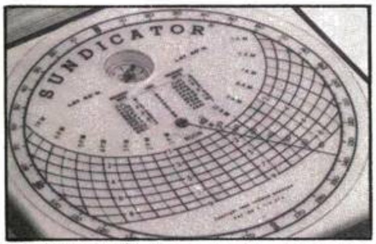

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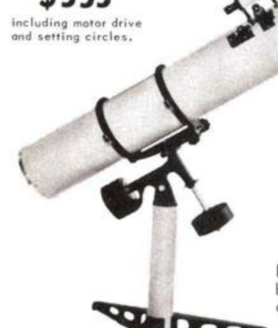

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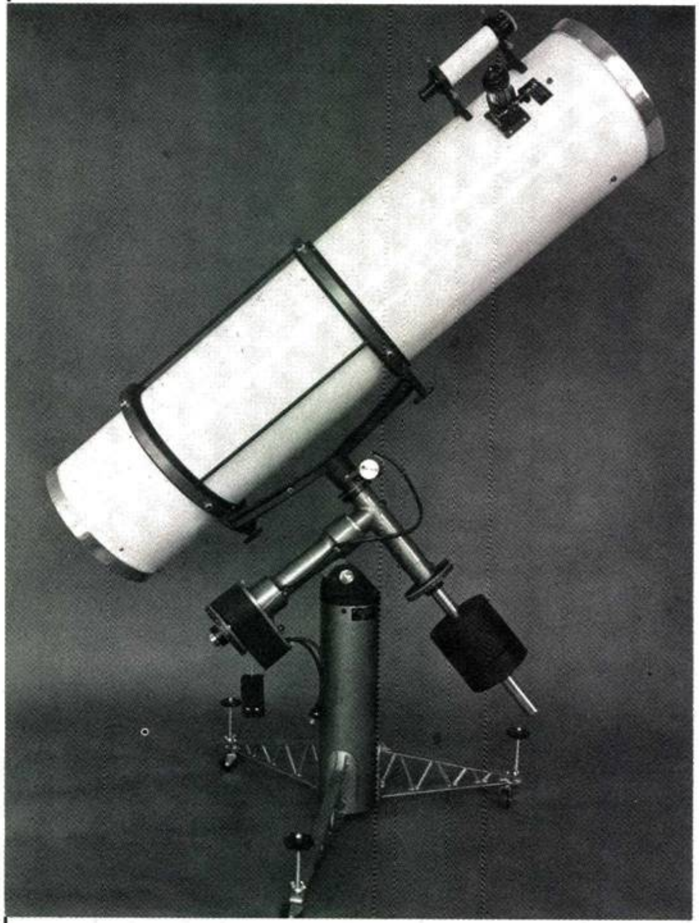

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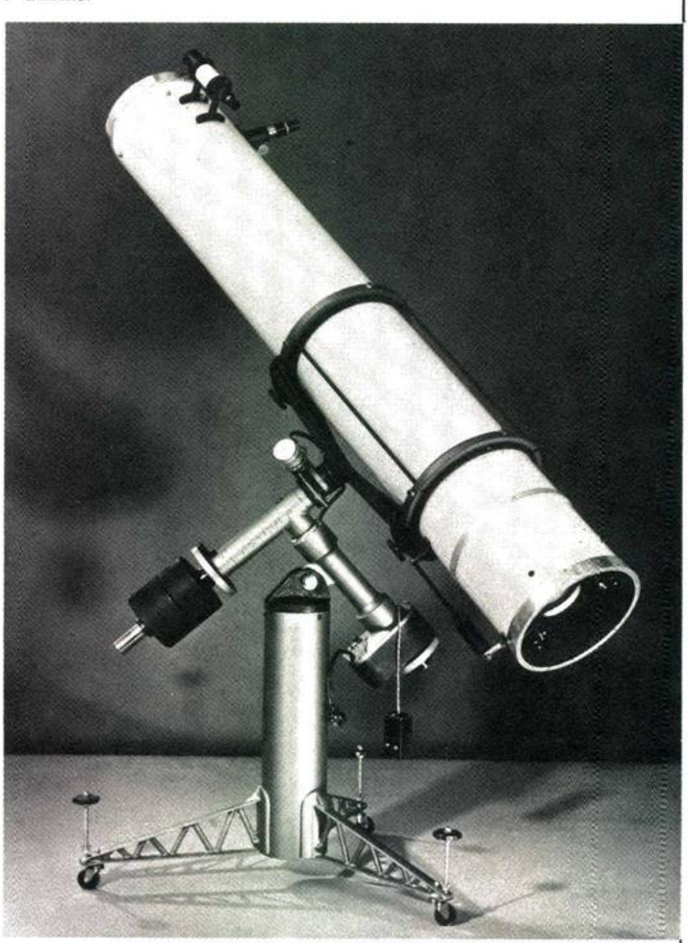

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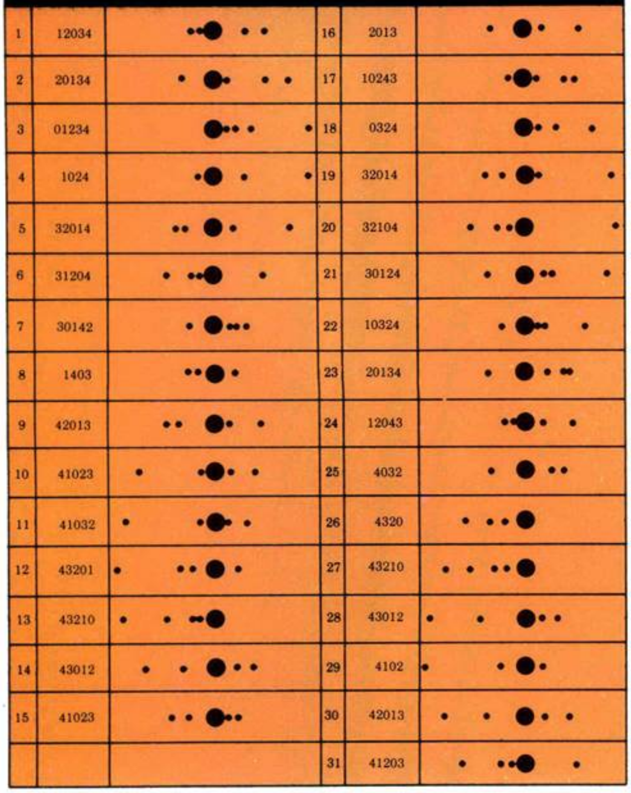
Ceres

Ceres is in opposition just before midnight (EST) on Dec. 1, but it comes closest to Earth on the 5th. These dates would be the same if Earth and Ceres had perfectly circular orbits around the sun; the four day lag is the result of their orbits being elliptical.

On the 5th, this largest asteroid will be only 162,000,000 miles away at magnitude +6.8 — easily visible in binoculars, if you know where to look. Using the map on page 39, you can locate the asteroid between fourth magnitude Delta and third magnitude Epsilon Tauri — inside the "V" of the Hyades open star cluster. Readers with setting circles can zero in on the minor planet at right ascension 4 hours

DECEMBER SATELLITES OF JUPITER

9:30 p.m. EST, 6:30 p.m. PST



1	12034	16	2013
2	20134	17	10243
3	01234	18	0324
4	1024	19	32014
5	32014	20	32104
6	31204	21	30124
7	30142	22	10324
8	1403	23	20134
9	42013	24	12043
10	41023	25	4032
11	41032	26	4320
12	43201	27	43210
13	43210	28	43012
14	43012	29	4102
15	41023	30	42013
		31	41203

Jupiter's four largest moons are so bright you can see them easily in even the smallest telescope. Orbiting swiftly around Jupiter in 2 to 17 days, their positions as viewed in a telescope change from night to night. Sometimes, especially when two moons are close to each other, their motions become evident with only a few minutes' observation. Eastern and Pacific Times are provided; subract one hour for Central Time, and add one hour for Mountain Time. First column (left) gives dates; second, the moons relative to Jupiter (1=Io, 2=Europa, 3=Ganymede, 4=Callisto, 0=Jupiter's disk); third, the approximate positions of the moons as seen in an "inverted image" astronomical telescope.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Dec. 1	2	9:54 p.m.	12:29 a.m.
3	1	12:47 a.m.	2:58 a.m.
4	1	7:16 p.m.	9:27 p.m.
5	3	12:21 a.m.	2:46 a.m.
9	2	12:31 a.m.	3:05 a.m.
10	1	2:43 a.m.	4:54 a.m.
11	1	9:12 p.m.	11:23 p.m.
16	2	3:07 a.m.	5:41 a.m.
18	1	11:08 p.m.	1:19 a.m.
26	1	1:04 a.m.	3:15 a.m.
	2	7:02 p.m.	9:35 p.m.
27	1	7:33 p.m.	9:44 p.m.

1=Io
2=Europa
3=Ganymede
4=Callisto

22 minutes 42 seconds, declination+18 degrees 18 minutes 54 seconds.

In a telescope, Ceres looks like a relatively bright, unblinking yellowish star. If you want to photograph it, there are two approaches: large scale, short exposure photographs or small scale exposures of an hour or longer.

With modern high speed films and a reasonably fast lens on a conventional 35mm camera, you can take constellation-scale photos — with exposures of 10 or 15 seconds — that show stars even dimmer than Ceres. And with such short exposure times, you don't need an equatorial mounting and clock drive — just a sturdy camera tripod (see "It's Simple to Photograph Constellations" in ASTRONOMY, November 1973).

You've probably seen long exposure star field photographs taken by observatories and astronomy enthusiasts that show an asteroid as a streak while the background stars are points of light. The asteroid moves swiftly in its orbit while the background stars that the camera is guiding on remain fixed; the streak represents how far the asteroid moved in its orbit during the exposure. This opposition of Ceres gives you an opportunity to try your hand at this sort of picture, if your equipment is sophisticated enough.

With stationary camera constellation photography, though, you can easily chart the motion of Ceres through the constellation Taurus by comparing photographs taken several days apart.

Ceres is only 426 miles in diameter, so you can't expect to see it as a disk. Still, it's well worth seeking out — if only "because it's there".

Conjunction of Venus and Uranus

Some two hours before sunrise on Dec. 11, early risers will have an opportunity to view Venus and Uranus as they pass within about two degrees of one another in the constellation Virgo. Two degrees is about four lunar diameters, so the planets will appear rather close together in binoculars.

Venus will be a gibbous, 2/3 illuminated disk while sixth magnitude Uranus shines like a tiny green jewel. It takes a large telescope and magnification of about 500 power to show Uranus as a disk, and even then its markings are dim and ambiguous. But conjunctions like this show off the planet to its best advantage.

Mars

Mars comes nearest Earth on Dec. 9, shining brilliantly at magnitude -1.5. Watch the red planet carefully this season because we won't get another close-up view until the opposition of 1978. (For details about observing Mars, see this month's Gazer's Gazette.)

Jupiter

At magnitude -2, Jupiter dominates the evening

Nova Cygni 1975 provided many readers the opportunity to keep their own astrophotographic record of this very rare event. The photo on the opposite page was taken Aug. 28, 1975 at 11:00 p.m. MDT using an Argus Cosina 35mm camera at f/1.8. High Speed Ektachrome was exposed for 10 minutes with camera riding piggyback on a telescope. This prediscovery photograph was made before the nova reached naked eye brilliance. The above photograph was taken Aug. 29 at 9:04 p.m. PDT, using Fuji R-100 film and piggyback astrophotography with camera lens at f/2. This was about one day before the nova reached maximum brilliance. The North American nebula shows distinctly in this photo and is situated between the nova and Deneb. Opposite: Photograph by Robert Harbrecht. Above: Photograph by John Sanford.

sky as it moves through the constellation Pisces this month. Its atmospheric belts and famous Red Spot are easily visible in a 60mm refractor telescope; even a pair of binoculars reveals the shifting positions of its four largest moons.

This month Jupiter moves farther away from us after its October opposition receding to 440,000,000 miles from Earth by Dec. 31. Still, in a telescope it presents by far the largest disk of any of the planets — more than 40 seconds of arc in diameter.

On Christmas eve this year there will be an especially interesting phenomenon — satellites 1 and 2 (Io and Europa, respectively) will pass behind the planet on the same night. Europa will disappear behind Jupiter's disk at 9:23 p.m. (EST) and at 2:46 a.m. will suddenly reappear some distance from the planet as it moves from the planet's dark shadow cone into the sunlight. Io will follow the same pattern at 2:34 a.m. and 6:04 a.m.

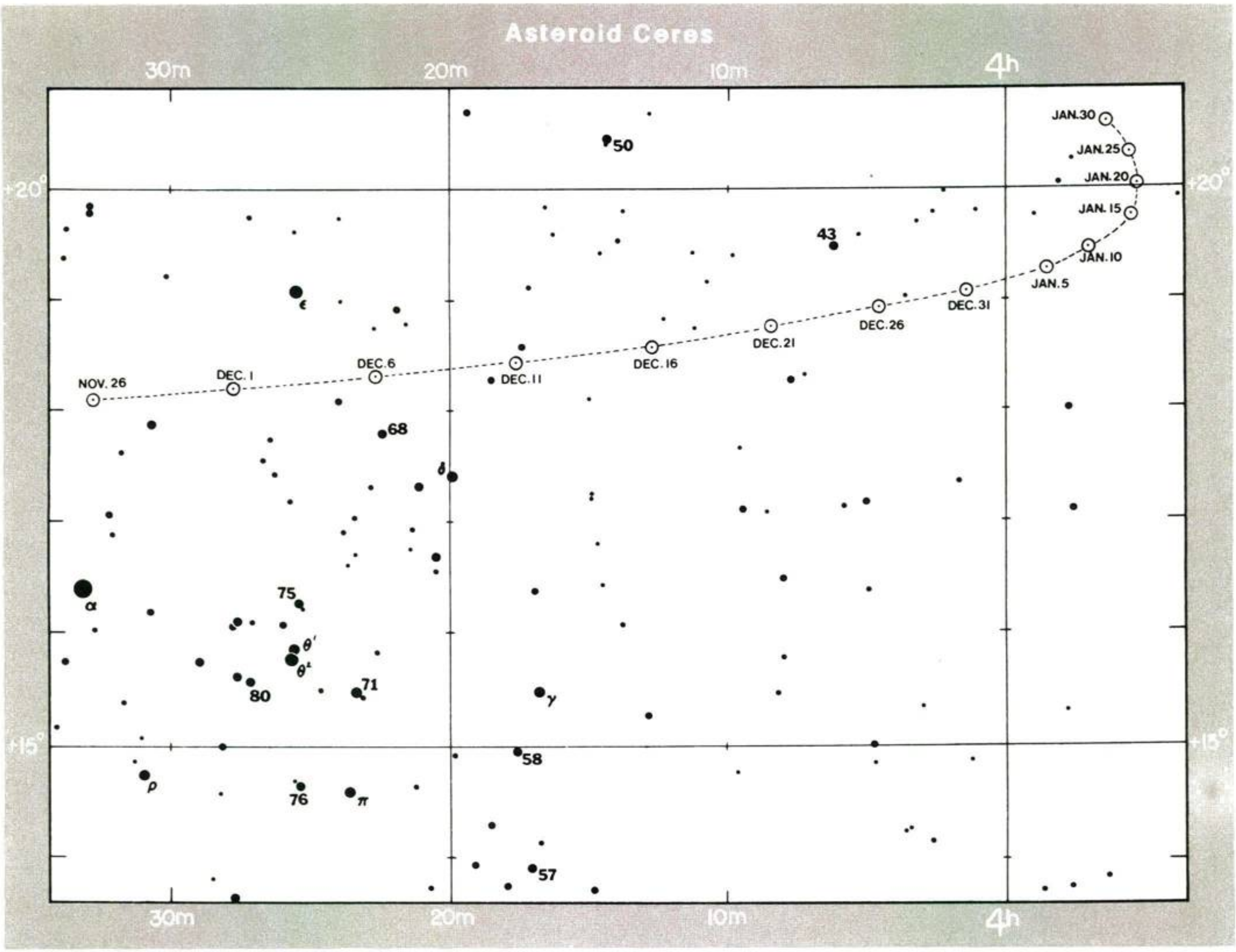
Ganymede, the planet's largest satellite (which was photographed in some detail by last year's Pioneer flyby), will also be occulted by Jupiter on the night of Dec. 29. It disappears at 9:01 p.m. and reappears 2 -1/2 hours later at 11:40 p.m. Ganymede is large enough to show a disk in a moderately powerful amateur telescope (an eight inch at 300 power should be adequate, given good seeing conditions).

Saturn

Saturn grows ever brighter as it moves toward opposition next month. It's in the constellation Cancer, rising shortly after the time the sun goes down.

(If you think a bit about the geometry of an opposition, it's obvious that *all* planets farther from the sun than Earth — outside our planet's orbit — will rise at sundown when they're in opposition. The planet and the sun are in exactly opposite parts of the sky — with Earth caught in the middle, so to speak.)

Saturn's rings, of course, are the most spectacular feature of the planet — perhaps the most breathtaking telescopic sight in the sky. In fact, if you're a sharp-eyed observer you might be able to detect the rings with 7x50 binoculars. They



won't show their true nature with so little magnification, however, but they can make the planet seem "out-of-round".

During December, Saturn's brilliance increases from +0.2 to 0.0. In a telescope it appears about 1/2 the size of Jupiter, growing to 20.5 seconds across by the end of the month.

The photo on the opposite page (top left) was taken from the Great Smoky Mountains of Tennessee at 12:30 a.m., Aug. 30. Nova Cygni 1975 was almost at maximum at this point, distorting Cygnus' familiar cross shape; while almost reaching the brilliance of Deneb, the nova remained the dimmer star at magnitude 1.8. The photograph at top right was made six days later on the evening of Sept. 5 from Ames, Iowa. A Minolta SRT-100 was used with lens wide open at f/1.9 during a 30 minute exposure on Kodachrome 64. The bluish background color is due to reciprocity failure in the film emulsion. Nevertheless, the nova was recorded as distinctly dimmer than on Aug. 30. By Sept. 9 the nova had become a dim, ruddy star — no longer visible to the naked eye as shown in the photo (bottom left). This eight minute exposure on GAF 500 was made with a Praktica camera. The 35mm lens was used at f/2.8; the camera was piggyback guided on a 3-1/2 inch Questar telescope. The photo (bottom right) reveals the nova's pinkish color on Sept. 13. No longer a naked eye spectacle, Nova Cygni 1975 will become a lesson in watchful preparedness. This was "only" a brilliant nova. We're about due for a spectacular supernova, so keep your eyes peeled. Top Left: Photograph by Charles Furguson; Top Right: Photograph by Gary Fanning. Bottom Left: Photograph by Jay Sarton; Bottom Right: Photograph by John Sanford.

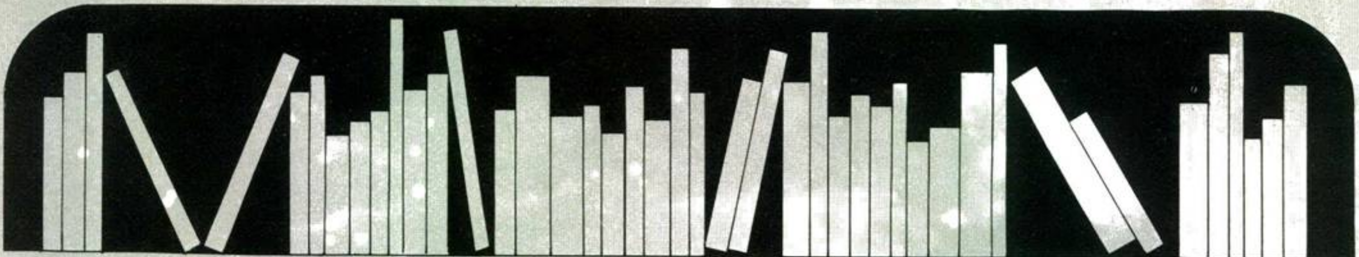
Titan, Saturn's largest satellite (large enough to retain a thin atmosphere), is easily visible in small telescopes. It goes around the planet in a little less than 16 days, so its motion is obvious in the course of a few days' observation.

Geminids

The Geminid meteor shower should give an interesting show this month. Classified as one of the most dependable showers after the August Perseids, the Geminid shower reaches its peak on Dec. 14 — but a few might be seen as much as a week earlier. Observers can expect to see 50 to 80 meteors per hour as the shower approaches its peak.

The best time to watch a meteor shower (or just to look for meteors in general) is after midnight. This is because before midnight, the night side of Earth is facing away from the direction it moves in orbit. After midnight, the night side of Earth is in the leading half of the globe, so the planet collects more debris.

Some showers can be a disappointment if strong moonlight interferes — especially during the post-midnight maximum. But we're in luck this year; the moon is just approaching first quarter on Dec. 14, and will have set long before midnight.



ASTRONOMY REVIEWS

The Next Ten Thousand Years
by ADRIAN BERRY

250 pages, hardcover, $8.95
Dutton (1974)

The future has had "bad press" lately. Outside of the optimism of "Star Trek", the coming years are characterized as overcrowded, polluted, depersonalized, shocking, enslaving and generally not very much fun. Things can only get worse, the mass media constantly assures us.

This book says differently. It is an entertaining, enjoyable effort by a British journalist to portray what he has heard might be good about the future. It is not a science fiction travelog ("We'll be on planet X by 1996, gee whiz!") but a potpourri of scientific philosophy, planetary engineering, cybernetics and assorted sneaky ways of exceeding the speed of light.

Berry recounts some suggestions for remodeling neighboring planets to make them easily inhabitable by Earth colonists. Venus can be seeded with blue-green algae to convert carbon dioxide into oxygen, lower the temperatures, and allow oceans to form. The moon and asteroids can be hollowed out or dismantled. Mars can be watered by ice imported from Saturn's rings and large satellites. These remarkable schemes are not original (Berry is careful to give credit to their originators) but could use the wider exposure which this book gives them.

The book is good journalism — imaginative, descriptive, enthralling and never boring. But it suffers from a journalist's faults; it is often shallow, uncritical, and occasionally incorrect when the author ventures beyond his own apparently meager scientific credentials.

For example, he refers to a "synchronous satellite of Venus" being constructed. A moment's thought should reveal why synchronous satellites can exist around Earth, Mars and Jupiter, but not around Mercury, the moon and Venus. The altitude of a satellite whose period was the same as the planet's "day" would be far too high in the latter cases, and the satellite would escape into interplanetary space.

A careful reader will not be as credible as Berry seems to have been when a scientist explains his theory of geometrodynamics: "A geon, though built of curved empty space and completely free of any so-called 'real mass', is nevertheless endowed — by reason of its radiation content — with a mass of its own. This mass holds it together against leakage losses for a time very long in comparison with the travel time of radiation through its interior..." The author should have looked for another opinion about this gobbledegook, but instead reports it straight.

Another example of where Berry reports on a scientific topic without understanding it, and subsequently gets it wrong, is in his description of the role of Jupiter and its moons in the first determination of the speed of light. "In 1671 the Dane, Olaus Roemer, used the different times of the year when Jupiter's moons were seen to be eclipsed — depending on whether Earth was approaching or receding from Jupiter — to make the first roughly correct estimate of the speed of light." By reporting this incident in such meticulous detail, Berry reveals that he had access to all the right information but missed the point entirely. Roemer noticed that the farther Jupiter was from Earth, the later were the easily predictable satellite eclipses. As the distance to Jupiter diminished, the satellites got back on schedule. He deduced correctly that the discrepancy was due to the time it took light to travel from Jupiter to Earth. Whether Jupiter was approaching or receding had nothing to do with it — Jupiter's absolute distance to Earth did make all the difference. Here as elsewhere, Berry clearly demonstrates that he is a reporter but not an astronomer.

So much visionary material is brought together here, however, that the book is a worthwhile counterpoint to current pessimism. If it appears overstated, remember the law of forecasting: Predictions tend to be over-optimistic in the short run and under-optimistic in the long run. Berry is very, very optimistic. *James E. Oberg.*

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The Telescope Handbook and Star Atlas
by NEALE E. HOWARD

226 pages (illus.), hardcover, $14.95
Thomas Y. Crowell Co. (1975)

For a book with "Updated Edition" printed prominently across its dust jacket, the 1975 version of **The Telescope Handbook and Star Atlas** is remarkably similar to the 1967 volume. The table of contents has not been altered; the charts and diagrams are mostly unchanged; even the number of pages remains exactly the same. On less than 10 pages, in fact, has anything been "updated" at all!

But so what! The first edition of this book was so well written that little could have been done to improve it. Although the author correctly points out in his forward that "ideas, information and techniques change very rapidly in astronomy", such recent information is largely irrelevant to the main purpose of a telescope handbook. This type of book should help the telescope owner understand his equipment, and then provide him with a good list of objects to find and observe. **The Telescope Handbook and Star Atlas** does an excellent job in fulfilling both of these objectives.

Howard has spent 30 years working with secondary school students, and this experience shows with his clear explanations and helpful suggestions. The first two chapters describe the "workings" of a telescope in great detail and yet are extremely easy to read and understand. And the chapters dealing with planets give the reader a very complete description of the features he can expect to find, together with good methods for making and recording his observations.

The Star Atlas, too, maintains the high standards of the rest of the book. The gazetteer includes many more than the usual collection of famous objects, but it does not waste space listing those objects that would be beyond the reach of a six to eight inch telescope. Every Messier object is described in detail, and it includes double stars, long and short period variables, and meteor showers. In addition, here is one place where updating *is* useful: Dates are given for upcoming eclipses of the sun and moon, as well as for the return of well-known comets.

Unfortunately, the Star Atlas section also includes the book's one glaring weakness — the star maps. Not only is the scale of these maps extremely small (10 degrees per inch), but translucent overlays are used to plot positions of nebulae and clusters making the maps almost useless. The small scale results in objects being crowded very close together (in the Virgo/Coma region, for example), and in some cases, register of the translucent overlays on the maps is so poor that it results in positional errors of several degrees.

In spite of this only shortcoming, **The Telescope Handbook and Star Atlas** should prove a very useful book for anyone owning a 2 to 12 inch telescope. It covers every aspect of observing and surely contains valuable information for almost any reader — young or old, experienced or inexperienced. The star maps are inadequate, however, and anyone who wishes to take full advantage of the rest of the book should plan to invest in larger, more precise maps as well. *Thomas C. Bretl.*

The editors of ASTRONOMY highly recommend this excellent reference book to its readers.

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A Random Walk in Science

compiled by R. L. WEBER
edited by E. MENDOZA

206 pages (illus.), hardcover, $12.50
Crane, Russak and Company (1974)

A Random Walk in Science is very much a mixed bag lacking in quality.

It is intended to give rare glimpses into science (particularly physical science) and scientists (mainly physicists). It includes 133 very diverse pieces — including photographs, cartoons and humorous poetry. The shortest selection is only two lines, and the longest two or three pages. The great variety includes the serious and the humorous, even the nonsensical. There is, for example, a glossary of "physics terms made easy" which includes these definitions: "graph — principal item of a cow's diet; watt — will you please repeat that remark?" Some of the pieces are the "great man" type — witty and apt quotations from, or anecdotes about, famous men in science who appear to be incorrigible practical jokers. James Clerk Maxwell and R. W. Wood are two who played ingenious and elaborate pranks. Maxwell once gave an introductory lecture on physics to an audience which included some of the greatest physicists of the time.

Another type of piece tends to be somewhat an "in" joke — for example, put-on mathematical proofs. There is one piece entitled "A Contribution to the Mathematical Theory of Big Game Hunting". The reader who doesn't have much formal background in science or mathematics will occasionally feel himself to be on the outside of the "in" jokes.

Though there is little here that has to do with astronomy specifically, not all of the material is equally edifying. But there is much here that is very entertaining, and it's all very readable. You will enjoy showing or reading certain parts to your friends. *Richard Stein.*

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Rescue in Space: Lifeboats for Astronauts and Cosmonauts

by ERIC BERGAUST

96 pages (illus.), hardcover, $4.69
G. P. Putnam's Sons (1974)

Rescue of space pilots whose lives are in danger in outer space is a fascinating topic; it may be of life and death importance to future astronauts. A reader trying to discover and understand the problems of space rescue will not be helped by this book at all. Instead he may be confused and misinformed by the errors, generalizations and misconceptions populating this brief work.

Spaceflight is indeed a dangerous venture, as the record already shows. Two Russian spacecraft have been lost with their crews, and at least three other American and Russian craft have brushed with disaster. Spacemen have also died in testing and training on Earth. Whatever insures their lives and a safe conclusion of their missions is crucial to future space exploration.

Bergaust covers the series of accidents in manned space flight through the end of 1973. Unfortunately, his chronology is often inaccurate — both in technical details and in major flight objectives and results. The four page appendix "Fate of Manned Space Flights" — weighted with errors — speaks poorly of research, compilation and proofreading. Ten year old illustrations — spectacular perhaps in the early 1960s — were anachronistic in 1974 (even more so now), mislabeled and irrelevant in many cases.

Covered briefly are the Skylab rescue plan (calling for a standby Apollo capsule) and the rescue implications of the 1975 Apollo/Soyuz project of one space crew by a second ship.

Excerpts from a concerned congressman's letter to NASA which form the backbone of an early chapter suggest that the space rescue capabilities were not built into Mercury and Gemini because of the haste and recklessness of the "race against the Russians". It is a disservice to the reader not aware of the considerations of a decade ago to suggest that NASA planners were not concerned with astronaut safety. In fact, most space accidents at that time would have killed the crew outright. Even a rescue ship flying alongside would not have saved the lives of the men. NASA used redundant systems to keep each spacecraft as failure proof as possible. That philosophy saved the crews of Gemini 8 and Apollo 13, but the Russian approach lost all on Soyuz I and Soyuz II. Rescue ships would have been useless to the endangered crewmen.

Nor is it inevitable that more men will die in space, as it was not inevitable that Apollo 1 crewmen suffocated in a capsule fire at the launching pad. The four Russian cosmonauts were not fated; their demise occurred because of human miscalculations. Good safety considerations, design and testing, plus onboard and Earth based rescue systems assist the safe exploration of space.

The author displays a common misconception of the nature of space orbits — a misconception understandable among laymen but unpardonable in an author-specialist in the field. Bergaust suggests that rescue ships could be "stationed in orbit" in order to quickly reach the scene of a space accident. That is clearly impossible due to the orbital mechanics which restrict a spaceship to its own orbital plane, a plane which rotates in space and usually does not coincide with the orbital planes of other spacecraft. Large fuel expenditures are required to change this plane even a few degrees. But a spacecraft fueled and waiting at a base on Earth is carried by Earth's rotation through the plane of any satellite twice a day — implying that a rescue mission should wait on Earth until a co-planar launch is possible. This simple truth is overlooked in this flaw-laden book.

Bergaust oversimplifies to the point of distortion and consequently his work is of little use to space engineers concerned with future space rescue. *James E. Oberg.*

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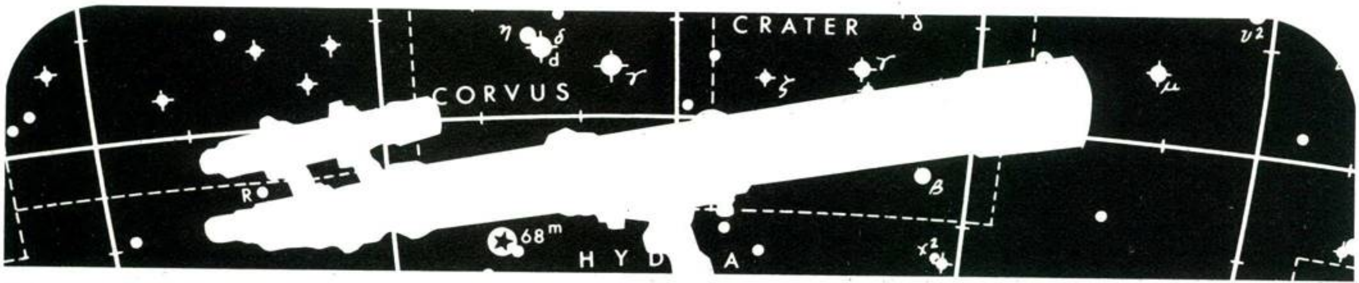


EQUIPMENT ATLAS

Tune Up Your Telescope

by
Thomas C. Bretl

Collimating your Newtonian reflector telescope may be one of life's little annoyances, but it's mighty important if you want your telescope to work right. Beginning astronomy enthusiasts especially — with so much to learn anyway — let themselves become defeated by adjustments they think are overly complicated and beyond their comprehension. Faced with the prospect of telescope collimation, more than a few beginners simply haven't allowed themselves to "graduate" from their small refractor to a moderate size Newtonian reflector.

The fact is, collimating a Newtonian telescope is just a shade more complicated than straightening a picture on the wall, and is a lot less confusing than tuning up a car.

Simply stated, collimating a Newtonian reflector is the process of aligning its two mirrors. More precisely, it means adjusting the angles of the reflector's primary (main) and secondary (diagonal) mirrors until an imaginary light ray could pass right through the middle of the diagonal, hit the center of the primary mirror, reflect straight back to the middle of the diagonal again, and bounce straight up the center of the eyepiece drawtube. The path this imaginary light ray travels through your telescope is called the *optical axis.* (Diagrams #1 & #2)

How do you know if your Newtonian's mirrors are out of alignment? If star images at the center of your eyepiece can't be focused no matter how carefully you adjust the eyepiece — that is, if images are fuzzy and elongated or look more like tiny parachutes instead of points of light — your scope needs alignment. Incidentally, even small misalignments rob your telescope of light gathering power and resolution. Easy double stars become impossible to split, and planetary detail blends into a "mush" that will lead to your eventual frustration if you don't collimate your scope. Four things throw a telescope out of whack: (Diagram #3)

1. The primary mirror and secondary diagonal may not be centered squarely in the main tube;

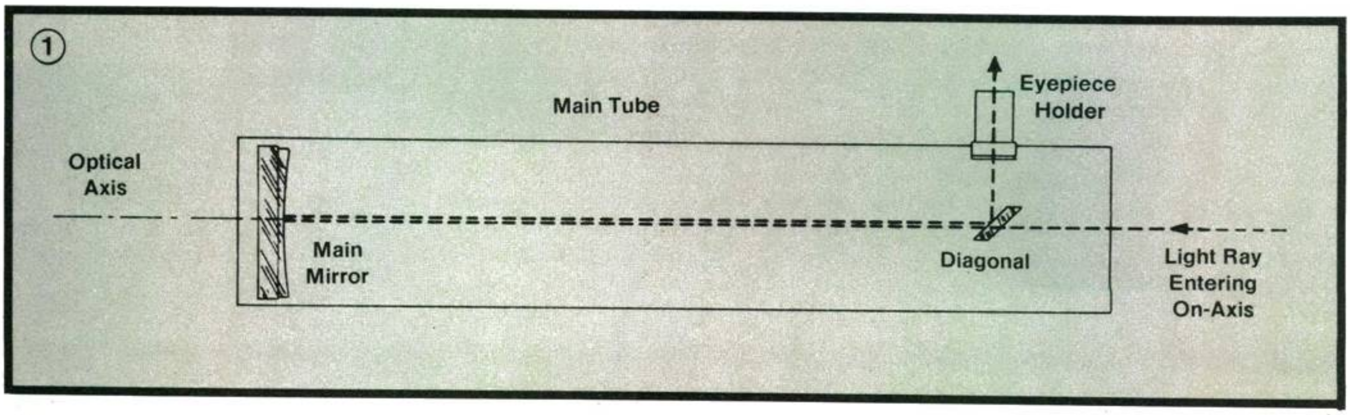
2. The eyepiece holder drawtube may not be squarely seated on the main tube (it may not point directly toward the middle of the secondary diagonal mirror);

3. The diagonal may be tilted at an angle away from the main mirror, and/or

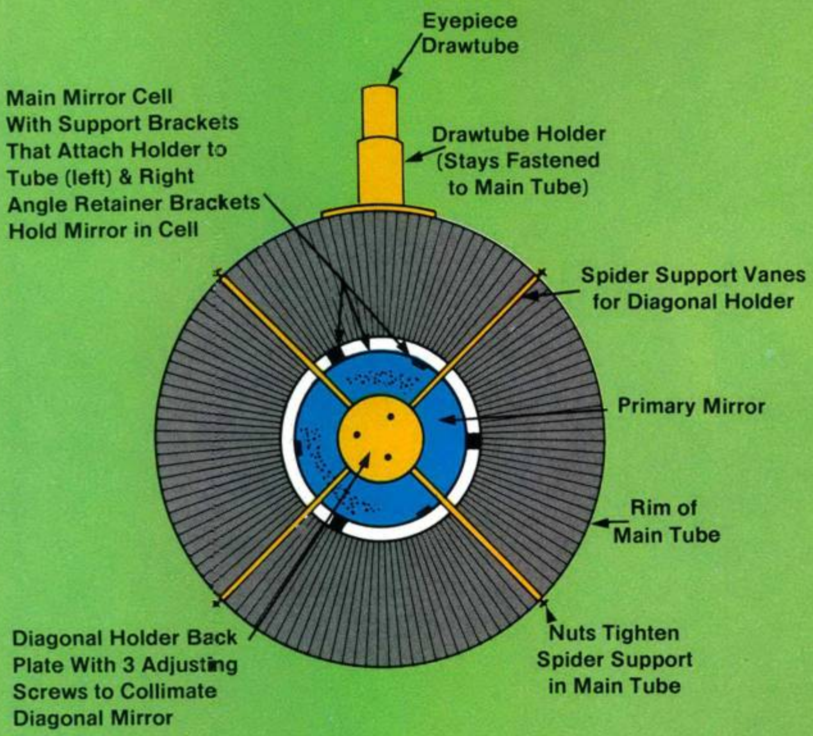
4. The main mirror may be tilted at an angle away from the diagonal.

With most commercially built telescopes, the

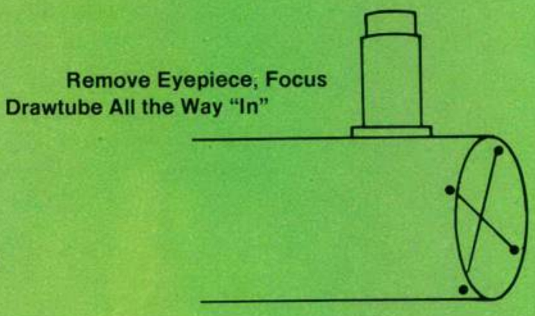
①



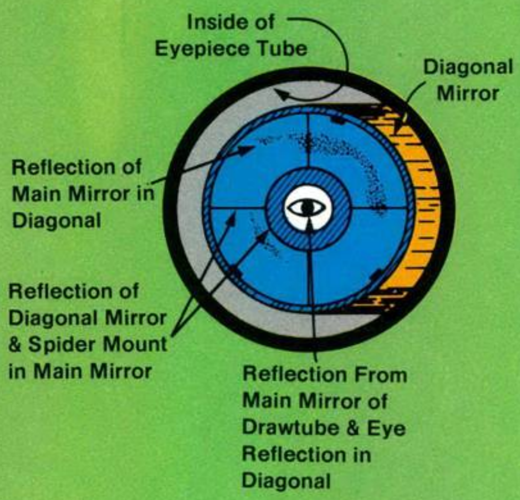
② Looking Down the Main Tube

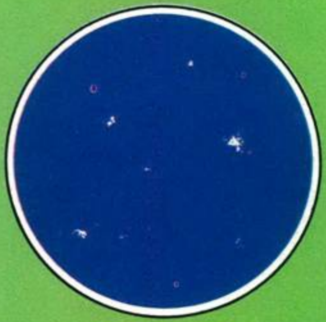

Eyepiece Drawtube
Main Mirror Cell With Support Brackets That Attach Holder to Tube (left) & Right Angle Retainer Brackets Hold Mirror in Cell
Drawtube Holder (Stays Fastened to Main Tube)
Spider Support Vanes for Diagonal Holder
Primary Mirror
Rim of Main Tube
Diagonal Holder Back Plate With 3 Adjusting Screws to Collimate Diagonal Mirror
Nuts Tighten Spider Support in Main Tube

④ Look Down the Eyepiece Tube


Remove Eyepiece, Focus Drawtube All the Way "In"

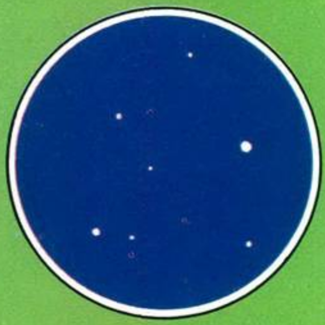
Here's What You'll See


Inside of Eyepiece Tube
Diagonal Mirror
Reflection of Main Mirror in Diagonal
Reflection of Diagonal Mirror & Spider Mount in Main Mirror
Reflection From Main Mirror of Drawtube & Eye Reflection in Diagonal



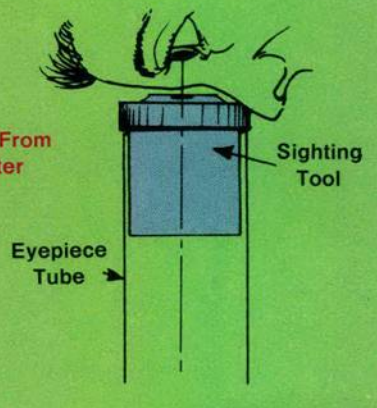
Uncollimated Optics

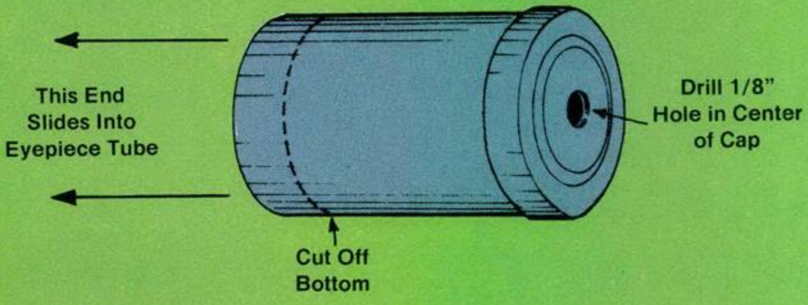
③



Collimated Optics

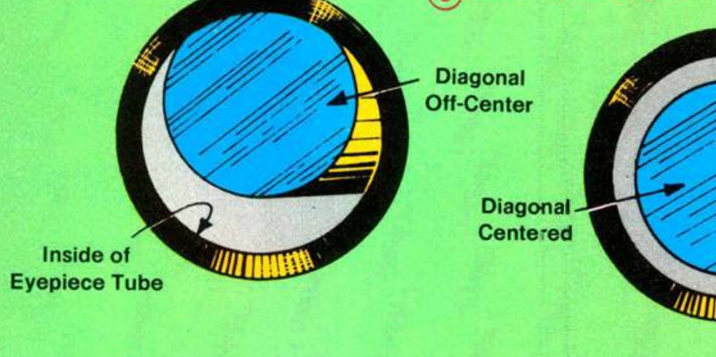
⑤ Make A Sighting Tool From a 35mm Film Canister

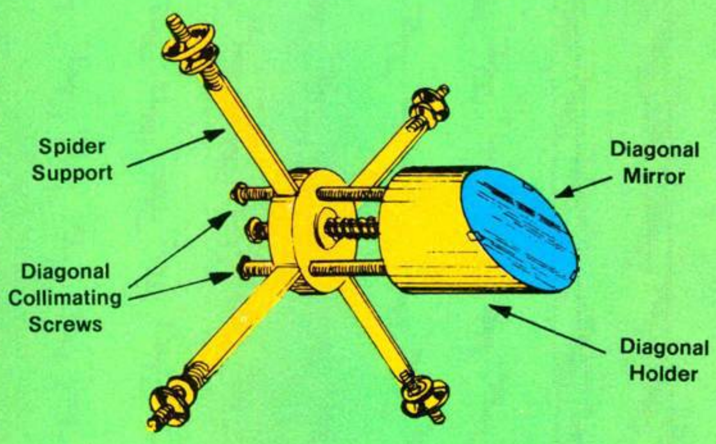

Sighting Tool
Eyepiece Tube


This End Slides Into Eyepiece Tube
Drill 1/8" Hole in Center of Cap
Cut Off Bottom

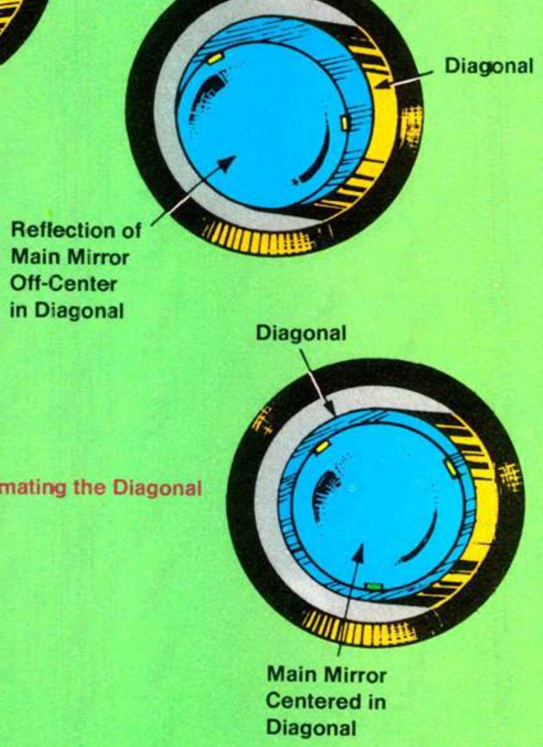
Artwork by Victor Costanzo & David Schwartz

⑥ Centering the Diagonal





⑦ Collimating the Diagonal



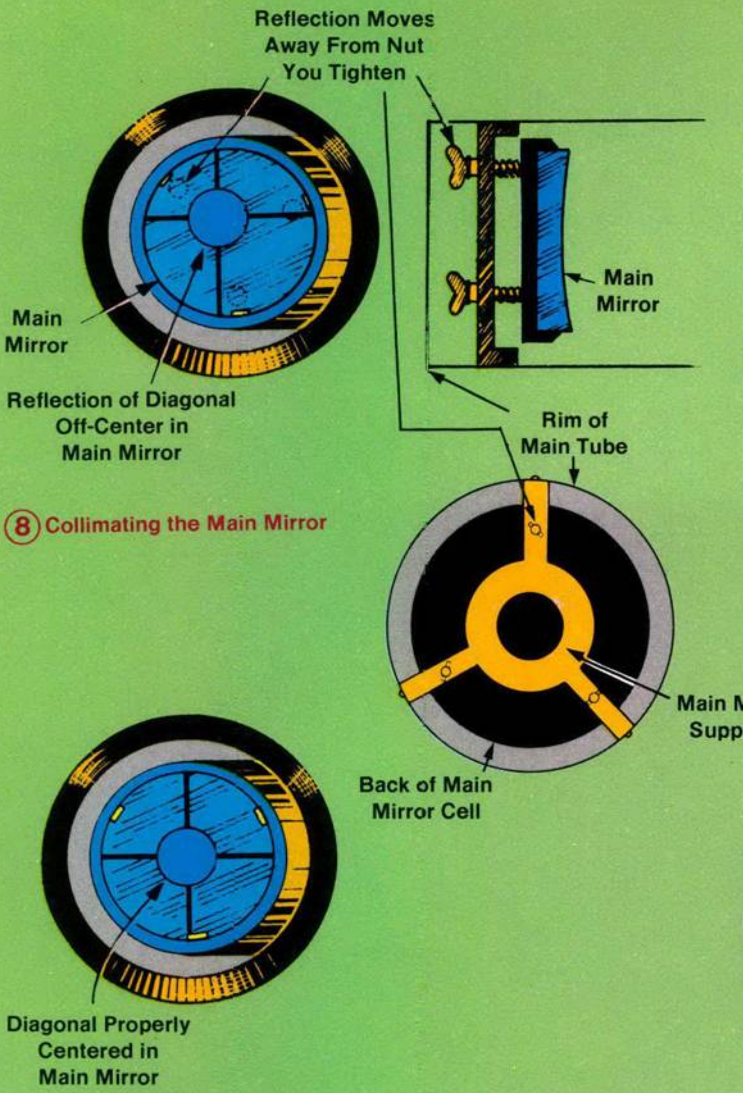
first two steps are done for you — and once done, seldom need readjustment. They insure that the optical axis of the two mirrors will coincide with the axis of the eyepiece, but even a small error does little or no harm. This being the case, you only have steps 3 and 4 to be concerned with.

First, remove the eyepiece from your telescope. Then look down the eyepiece holder drawtube. If you have the tube focused "in" as far as possible and your eye right up next to it, you should be able to see the entire outline of the main mirror reflected in the diagonal. Within this reflection will be a much smaller double reflection of the diagonal itself, and within that image is the triple reflection of the drawtube and your eye. Think about what you are seeing and why. Light has traveled down the drawtube, reflected off the diagonal once again and finally returned to your eye. You will probably also notice all those reflections are not very well centered within each other. This means the telescope is not yet properly collimated. (Diagram #4)

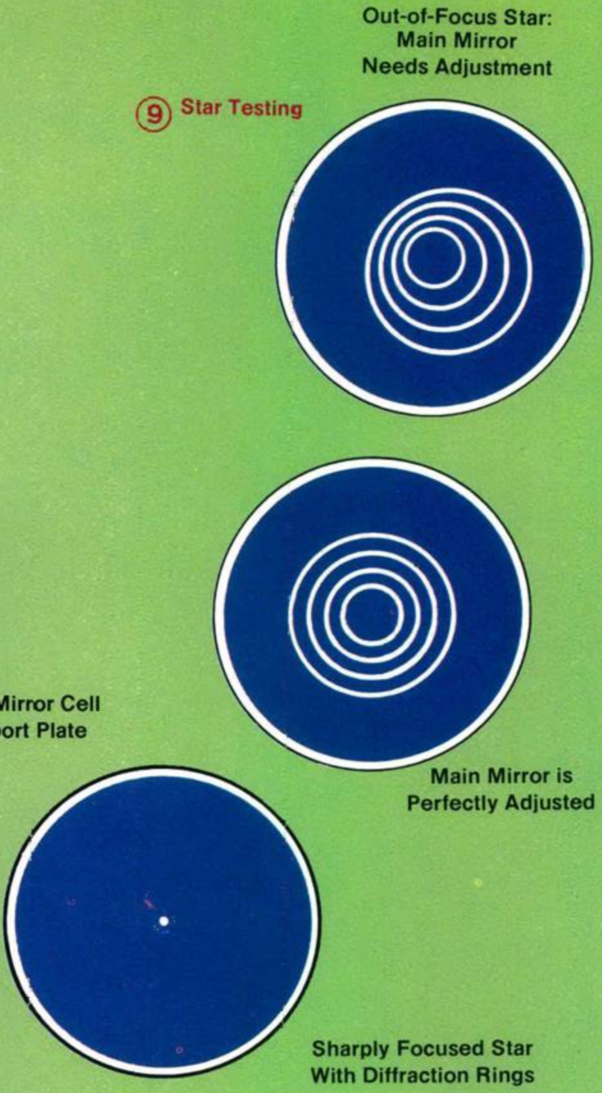
To help you align the telescope mirrors accurately, it is a good idea to make a simple sighting tool. This is easily done by cutting off the bottom of a 35mm film canister and drilling a 1/8 inch hole in the middle of its cap. Fortunately the canister slips easily in and out of a standard 1-1/4 inch eyepiece holder. Look down the drawtube again — this time using the sighting tool. Your eye is now "fixed" in the center of the drawtube, so any signs of bad alignment are due entirely to the positions and angles of the mirrors. (Diagrams #5 & #6)

Now check to see if the diagonal mirror appears centered within the circle formed by the far end of the eyepiece drawtube. If it is not, adjust the diagonal holder's position within its support (the spider) until it looks about right. This is not a critical adjustment, but it helps to make sure that none of the light gathered by your telescope will be wasted. (Diagram #7)

Next, look at the reflection of the main mirror in the diagonal. Is it centered? Since its reflection is almost as large as the diagonal itself, it shouldn't be too difficult to judge. Just make sure there is an equal "margin" of diagonal mirror all the way around the reflection of the main mirror. If not, change the angle of the diagonal. This is most commonly done by adjusting the tension on three small screws extending from the spider to the diagonal holder. At first your efforts will probably seem to make the situation worse, but soon you will learn how each screw affects what you see. Continue making adjustments a little at a time until the primary mirror's reflected image looks centered. (Diagram #8)


Reflection Moves Away From Nut You Tighten
Main Mirror
Main Mirror
Reflection of Diagonal Off-Center in Main Mirror
Rim of Main Tube
Main Mirror Cell Support Plate
Back of Main Mirror Cell
Diagonal Properly Centered in Main Mirror

⑧ Collimating the Main Mirror


Out-of-Focus Star: Main Mirror Needs Adjustment
Main Mirror is Perfectly Adjusted
Sharply Focused Star With Diffraction Rings

⑨ Star Testing

Finally, try to center the small double reflection of the diagonal mirror in the middle of the primary one. This is accomplished by adjusting the wing nuts on the back of the main mirror mount. Once again, proceed by trial and error. Eventually you will get an instinctive feel for how each wing nut moves the diagonal reflection in a different direction. Because the diagonal's reflection is much smaller than the area it must be centered on, you may find it difficult to know when to consider the job done. Again, there is no need to worry. A fairly good job at this point is acceptable since you'll use a star image for the final check.

Wait for a night of good seeing, select a star of about third magnitude, and center it in the field of a moderate power eyepiece. Now put the star out of focus. Do you see a number of bright rings surrounding the star's original position (with the shadow of the diagonal holder in the middle)? If the angle of the main mirror is well adjusted, these rings should be perfectly concentric — centered on the star image and an equal distance apart on all sides.

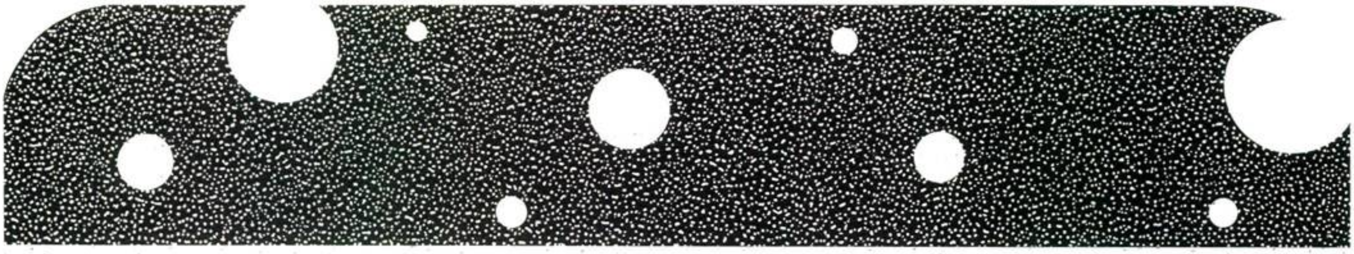
On the other hand, if the rings are closer together on one side than the other, distorting coma is present. As before, turn the wing nuts on the mirror mount and try to make the rings concentric. Proceed slowly — even a small change in the mirror angle will have a noticeable effect.

Once you make the rings concentric using a moderate power eyepiece, repeat the test at higher magnification. At this point, just 1/8 turn of one nut will probably be the maximum adjustment needed. Then focus the star as sharply as possible; your reward — a beautiful, small, almost pointlike image surrounded by only one or two faint diffraction rings. Suddently a patient collimating job will seem worthwhile! (Diagram #9)

So there you are — it's not really confusing after all. But if you're still a little hazy on aligning your Newtonian, get your scope out of the closet (or wherever) and put it out of whack on purpose to get collimation practice. Following these instructions, once you start collimating your own telescope, you'll find it a lot easier than you think.

To readers who think they "can't" collimate a Newtonian, and hesitate to buy one because of it — nonsense! There's a new world of large aperture out there just waiting to take you on a journey through the beauty of the universe. Isn't it worth the effort?

Sternbach



STELLAR FRONTIERS

We Are Alone!

by

Gerrit L. Verschuur

"As difficult as finding a needle in a haystack" — that's the incredible task facing the scientist trying to find proof of intelligent life in other star systems.

Think about it. Are there really other civilizations out there — like ours — with which we might someday carry on a conversation?

What an intriguing question — and what a fantastic reward if the answer is yes! So the search goes on. Our intrepid scientific hunter maintains his vigil, but lives with the nagging suspicion that there may not even be a needle to be found in his haystack.

What are his odds? What are his chances of finding such a community? While much has been written about how we might recognize a signal from an extraterrestrial caller, little has been said about real number prospects. However, one method for calculating such an estimate was proposed by Frank Drake at a 1971 conference on life in the universe.

Drake's formula utilizes: the rate of star formation in the Milky Way; the fraction of these stars that develop planets; the number of such planets ecologically suited for life; the fraction of planets on which life actually evolves; the fraction of those on which life then evolves to intelligence; the fraction of those that become communicative over interstellar distances, and the lifetime of the civilization in the interstellar communicative phase.

After careful thought, appropriate values were assigned to each element in this long equation. The estimate of our odds could then be distilled to the miniequation $N = 1/10\ L$. (N equals the number of intelligent civilizations that might be able to communicate with us; L is the lifetime of the civilization in the interstellar communicative phase.)

The remarkable meaning of this is that the number of societies now around the galaxy for us to "direct dial" is related to how long they — and we — remain in our respective interstellar communicative stages of development.

This isn't too surprising, since we will certainly have a better chance of contacting a civilization that's around for a long time than we will a short-lived one. In the latter case, there is just too little likelihood that we will both be at the same stage of evolution at the same point in time.

Unfortunately, there is no accurate means of establishing what length of time L represents. The only experience we have with such a society is ours — and it is still anyone's guess as to how long we will survive.

With this in mind, let's examine some of the possibilities. If we assume that the lifetime of a technological society is between 100 and 200 years, we would find no more than 10 to 20 civilizations like ours in the entire Milky Way.

If distributed uniformly throughout our galaxy, the closest of our similar civilizations would be more than 2,000 light-years from us. Obviously, trying to find such a civilization is akin to finding our proverbial needle. There are literally tens of millions of stars within 2,000 light-years of Earth.

Even if we could pinpoint one particular star that we were certain had life like ours, time alone would prevent us from communicating with it. Traveling at the speed of light, it would take more than 4,000 years to simply exchange "hellos" via this interstellar telephone.

Recalling the approximate two second delay that occurred when NASA's Mission Control talked with our men on the moon, it's easy to see that we

About one year ago, a computer message burst from the 1,000 foot wide radio telescope at Arecibo, Puerto Rico and started a 24,000 year journey to the globular star cluster M-13. Even if the message is received and understood — and even if an alien race replies — will Earthlings of 49,974 be interested in listening? If Cro-Magnon man emerged 50,000 years ago, will humankind of that equally distant future have evolved to interstellar deafness? And even if we are still technological — actively seeking interstellar communication and listening for replies from distant aliens — what is the likelihood that the M-13 race will still exist at all when Earth receives its 24,000 year reply? Artwork by Rick Sternbach.

Like looking for a needle in a haystack — that's what man faces in his search for life elsewhere in the universe. But the odds we face in our "isolated" corner of the galaxy would be much lower for a technological, communicative race inhabiting a planet orbiting a star in the globular star cluster, M-13. Here, where interstellar distances are less than a light-year and where many stars are available for life's search, races could develop considerable intercommunication (maybe trade) over a span of 200 years. Perhaps we will never be so fortunate. Hale Observatories photograph.

are unlikely to communicate with a society thousands of light-years away.

More significantly, our definition limits the lifetime of these civilizations to 200 years or less. Thus, by the time we received their radio signals, their evolving society might no longer exist in a communicative state. Similarly, by the time someone received our signals, we too might have reached a new epoch in our historical development. Consequently, for a small value of L, we appear to be effectively alone in our galaxy.

Therefore, it seems that the only opportunity we may have of actually contacting another civilization is if the number of advanced societies is very large. That would put each community relatively close to others like it. For that to be the case, L in the miniequation would have to be very, very large. If, for instance, L is as great as 10 million years, there would be a million sister societies around for us to attempt to reach.

Even then, our task would not be simple. The nearest communicating star system would still be a staggering 100 light-years away. This in turn would mean that a single message and subsequent response would take at least 200 years to complete. And that doesn't allow any time for the people on either end to decipher the signal.

Of course, there are other factors which would influence our chances of locating another communicative society. Among them is the fact that we are most apt to contact beings who are similar to us in both form and method of communicating — life as we know it.

Although there may well be other life forms out there, that doesn't count — we would never be able to initiate a conversation with them.

To illustrate this point, we might consider apes in our zoos. If in some thousands or millions of years they became capable of talking as we now do, chances are that we still would be unable to exchange ideas or discuss concepts with them. In the same time span our own evolution would have continued; we, too, would be communicating in a completely different manner.

It is much like trailing someone on the escalator in a tall building. No matter how long you ride on your respective escalator step, the distance between the two of you remains the same.

Also affecting the likelihood of our ever talking to another galactic community is the basic question of our own survival. Will we survive long enough in the communicative state to realize this goal? After all, this desire to communicate with other star systems is a manifestation of our present environment. We may someday conclude that this experiment is not truly beneficial to us, and simply discard it in favor of searching a more immediate haystack.

Furthermore, we may evolve to a point where we no longer communicate with spoken words. Man's old dream of mental telepathy may become his evolutionary destiny. Or, the more recent nightmares of nuclear annihilation, overpopulation or destruction of the environment might occur to end the opportunity for many eons.

Returning to our numbers game, we have pointed out that the most crowded galaxy we can imagine would still force us to conduct our hypothetical conversations over periods of many hundreds of years. For stars so close to each other to be inhabited now, the average civilization would have to survive a very long time indeed — perhaps billions of years.

To say the least, this seems unlikely. If we consider only the pattern of life on this planet, it is clear that change is the rule — not the exception. It is simply unrealistic to believe that society on this planet, or any other planet, will be remotely similar for a thousand years — let alone a million or billion years. We frequently can't even guess intelligently about next year — so how could we ever dream that the all important L in our equation might be more than 100 years or so?

For anything else to be true, we would have to assume that advanced civilizations reach an evolutionary plateau. It is only in that instance that we can consider the prospects of making contact with another civilization to be greater than zero. Now, the history of man's existence on Earth certainly has not as yet exhibited such a plateau. Of course, it can be argued that the dinosaurs inhabited Earth in a comparatively stable form for millions of years — and that man could also experience a similarly long period of stability.

If this is the case, however, then we have clearly just entered such an unvarying era. Ten thousand years ago, we still inhabited caves; the changes we have experienced in just the last century are staggering. If we are now to settle down for a period of 10 million years or more, and if this is a typical occurrence throughout the galaxy, then — and only then — are there likely to be the large numbers of civilizations needed for us to have even a remote prospect of contacting them. But who among us can imagine such stability — or should we say stagnation — setting in now?

This prospect certainly seems unlikely. We have just developed the ability to communicate on an interstellar basis. Now we appear to be totally engrossed in the task of putting our new tools to work.

After all, man arrived at the threshold of this capability only when radio was invented. This provided the first speed-of-light communications, and things haven't been the same since. However, a number of years passed before we developed our new tool to the point where we could actually exchange messages with another society in our galaxy.

In terms of the quality of our present day equipment — radio telescopes, radar transmitters and receivers — our skills are very new. It was only in 1975 that we could truthfully say that we were able to accomplish such a feat. By use of the 1,000 foot diameter radio telescope in Arecibo, P.R., we can at last communicate with a society located anywhere in the Milky Way.

Of course, radio and television signals have been venturing forth for more than 40 years. Civilizations within that number of light-years are now hearing from us. However, this cannot be realistically called communication.

After all this, you may well ask if the virtually certain existence of unidentified flying objects does not refute the pessimistic outlook presented here. The answer is to the contrary.

Based on the length of time required for Earth to be visited from outer space, the home planets would have to be relatively nearby. In that instance, the UFO civilization would have to exist unchangingly for millions of years because it is unimaginable that they have traveled for thousands of light-years to arrive at our doorstep. This bespeaks a static — even dull — society. It is a far more intellectually gratifying experience to believe that they are delightful alternatives that involved Earth and its peoples.

Taking all of these factors into account, the obvious conclusion is a bit pessimistic. It appears impossible for short-lived civilizations to contact each other, while long-lived societies are hundreds of light-years apart. Given man's present penchant for impatience, we can hardly claim to be communicative on the time scale required for interstellar discussions.

The inevitable conclusion that evolution never stops leads to the assumption that L is a small number. If this is the case, it follows that we are effectively alone in our little corner of the Milky Way. Civilizations light-years away might as well not exist. We shall never contact them; we will never find the needle in our interstellar haystack.

We are alone in space!

Let's hear from you. We invite you to comment on this opinion, but please limit it to 400 words or less. Look for a forum of reader reactions in coming issues.

GAZER'S GAZETTE

Mars at Opposition

by

James Mullaney

Ancients called it the god of war; Percival Lowell mapped canals on its surface; Mariner spacecraft beamed us images of its stark, crater pocked wastes. Yet mankind's fascination with the red planet Mars continues.

This December, astronomy enthusiasts can share in Mars' exploration as it swings again to opposition.

Oppositions occur every two years when Earth — which takes 365.4 days to orbit the sun — passes Mars on its 686.9 day journey around our star. Once every 15 to 17 years, when Mars is closest to the sun, this distance can shrink to 35 million miles.

This month on the 15th, Mars will be 52.6 million miles from Earth. While this is the official date of opposition, orbital mechanics of Earth and Mars will bring the two planets closest on Dec. 8. The best time to observe Mars is just shortly before or after the 8th. It will still be an interesting telescopic sight through the end of January, however.

During this fleeting space rendezvous, you will have an opportunity to record close-up details on Mars. All you need is modest equipment — and a few tips.

Equipment

Under stable atmospheric conditions, even a 2.4 inch refractor will show the Martian polar caps and prominent surface features such as the wedge shaped plain, Syrtis Major. These small instruments will also reveal the slight gibbous phase displayed by the planet before and after opposition.

While a small telescope reveals a few interesting Martian views, four to six inch aperture telescopes allow detailed observations that will keep you busy for weeks. Larger instruments up to 12 inches allow serious, semiprofessional study of the red planet (though larger apertures rarely improve detail visibility because of their increased sensitivity to atmospheric and thermal disturbances).

Serious planetary observation demands a first-class telescope with high quality optical components and a sturdy mounting; requirements for observing Mars are no exception. With its fine surface and atmospheric detail, its subtle contrasts and colors, Mars is the most optically demanding of all the nearer planets.

Since Mars watching is usually done for extended periods at high magnifications, an equatorial mounting with clock drive is almost essential. Useful, too, is a comfortable chair or ladder to make the vigil more bearable.

Experienced planetary observers find that 30 to 50 power per inch of telescope aperture is the ideal magnification to use on Mars. For example, a four inch instrument yields best results at 200 power, while an eight inch telescope performs well at 400 power.

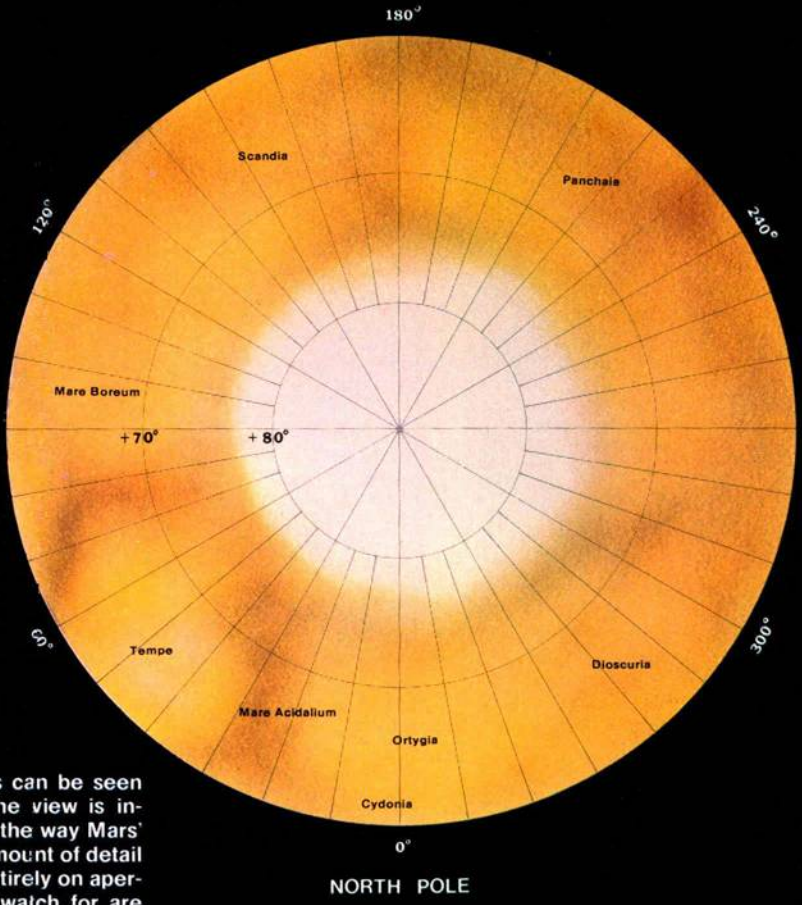
The use of well-corrected eyepieces — preferably orthoscopics — and an achromatic Barlow lens helps optimize viewing.

Training Your Eye

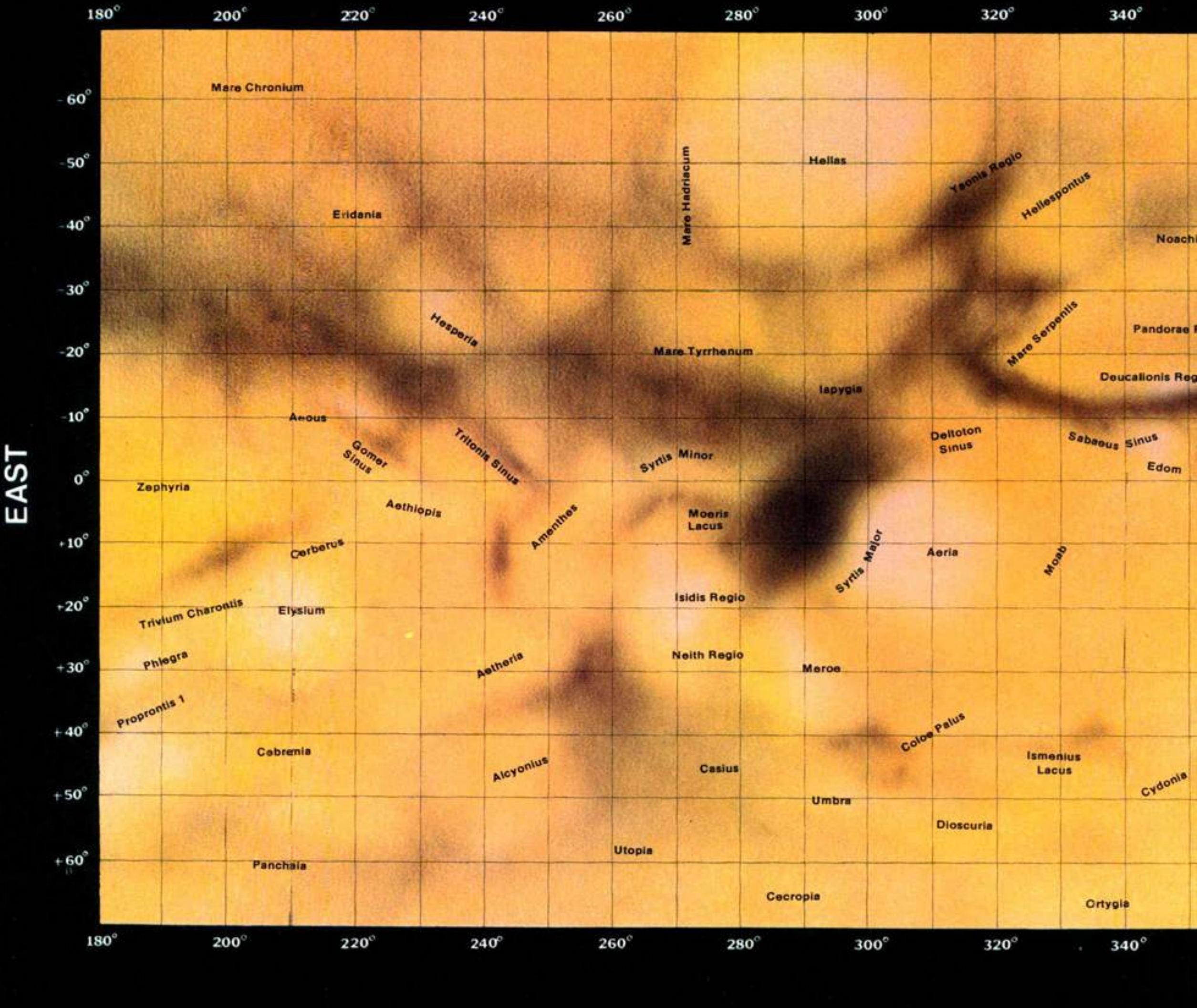
If you've never looked at Mars through a telescope, your first glimpse may only reveal an orange pulsating blob of light that may be downright disappointing. However, as your eye is trained from night-after-night scrutiny of the planet, you will quickly begin to see detail that escaped you initially.

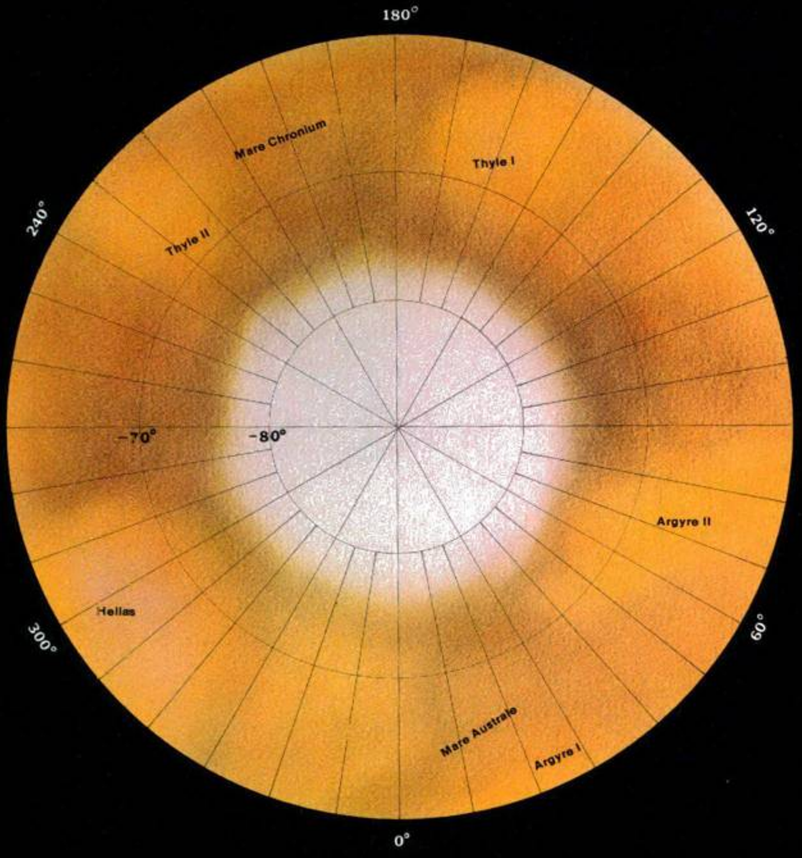
One exercise you can try in preparation for observing Mars is to frequently sketch detail of what you see on the surface of the moon without a telescope. Do this every clear night for a month — say, from full moon to full moon. Then compare your drawings to each other and with small scale photos or maps. You will probably find that your moon drawings became increasingly more detailed as the month progressed; there may even be a dramatic difference between your first full moon drawing and your last. Such an activity will quickly train your eye for planetary study, almost making you an

Mars reaches opposition this month, and its telescopic appearance will be similar to the way it looked during its 1969 approach when this photograph was made. Here Syrtis Major is dark and prominent at the center of Mars' disk. Wispy clouds can be seen over both poles; south is at the top to approximate the planet's appearance in an inverting telescope. Note the apparent clouds on the left (eastern) limb of the planet — this is evening haze. Lunar & Planetary Laboratory photograph.

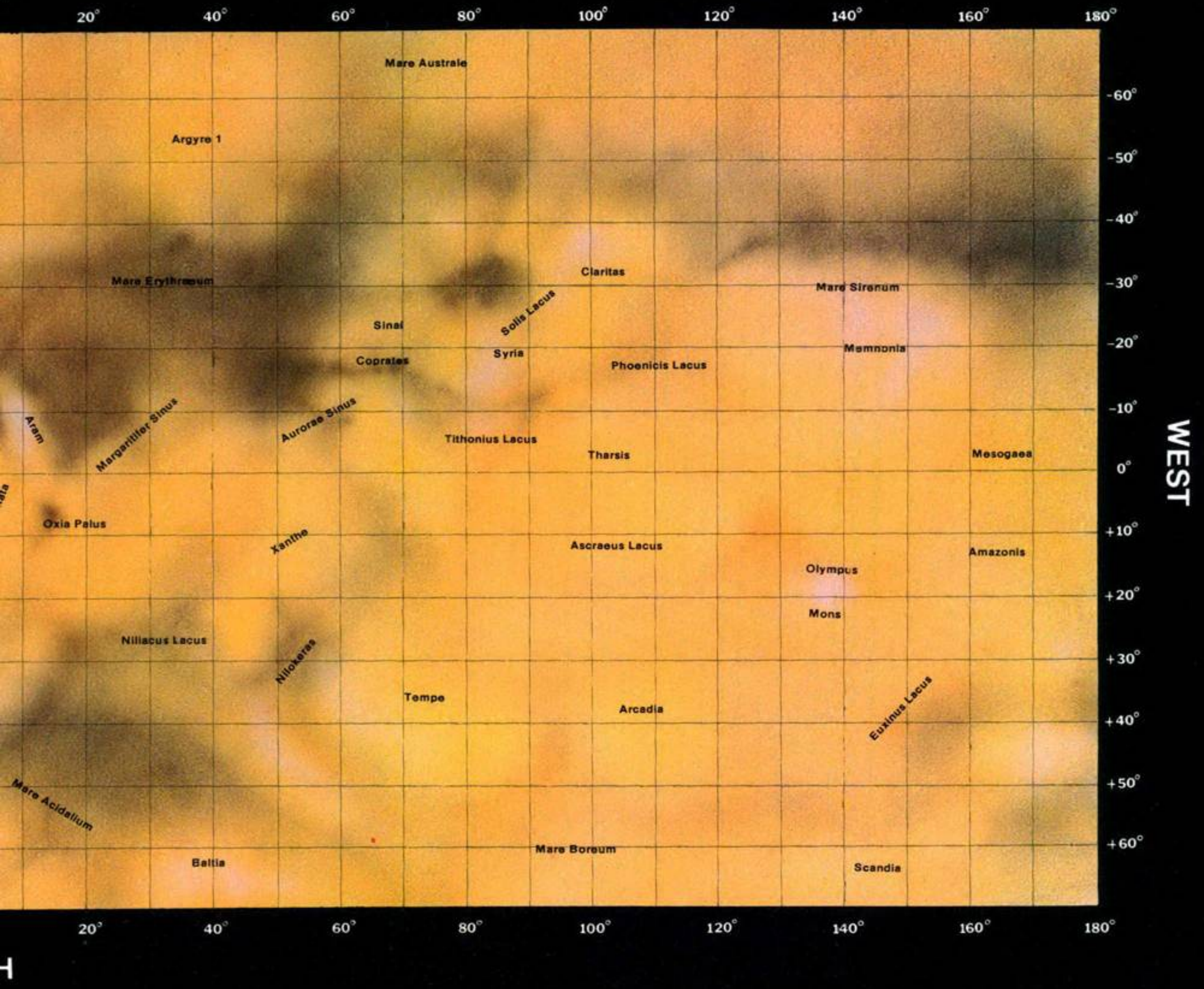

180°
Scandia
Panchaia
120°
240°
Mare Boreum
+70°
+80°
60°
300°
Tempe
Dioscuria
Mare Acidalium
Ortygia
Cydonia
0°
NORTH POLE

Most of the major features on this map of Mars can be seen with telescope apertures of 8 to 10 inches. The view is inverted (south is at the top), so it corresponds to the way Mars' image looks in an astronomical telescope. The amount of detail you actually see with your telescope depends entirely on aperture and seeing conditions. Other features to watch for are whitish or yellowish clouds. Map by Victor Costanzo.


180°
200°
220°
240°
260°
280°
300°
320°
340°
EAST
-60°
-50°
-40°
-30°
-20°
-10°
0°
+10°
+20°
+30°
+40°
+50°
+60°
Mare Chronium
Mare Hadriacum
Hellas
Yaonis Regio
Hellespontus
Eridania
Noachi
Hesperia
Mare Serpentis
Pandorae
Mare Tyrrhenum
Deucalionis Reg
Iapygia
Aeolis
Gomer Sinus
Tritonis Sinus
Syrtis Minor
Deltoton Sinus
Sabaeus Sinus
Edom
Zephyria
Aethiopis
Amenthes
Moeris Lacus
Cerberus
Syrtis Major
Aeria
Moab
Trivium Charontis
Elysium
Isidis Regio
Phlegra
Aetheria
Neith Regio
Meroe
Propontis 1
Coloe Palus
Cebrenia
Alcyonius
Casius
Ismenius Lacus
Umbra
Cydonia
Dioscuria
Utopia
Panchaia
Cecropia
Ortygia


180°
Mare Chronium
Thyle I
240°
120°
Thyle II
-70°
-80°
Argyre II
Hellas
300°
60°
Mare Australe
Argyre I
0°

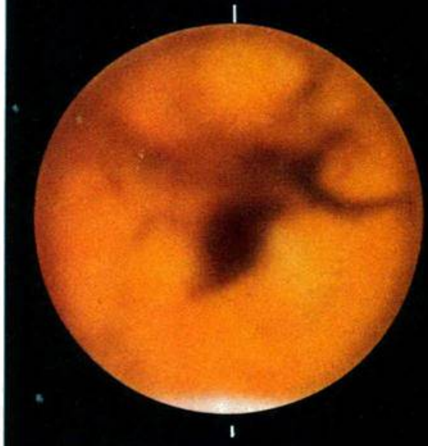
SOUTH POLE


20°
40°
60°
80°
100°
120°
140°
160°
180°
Mare Australe
Argyre 1
Mare Erythraeum
Claritas
Mare Sirenum
Sinai
Solis Lacus
Coprates
Syria
Phoenicis Lacus
Memnonia
Aram
Margaritifer Sinus
Aurorae Sinus
Tithonius Lacus
Tharsis
Mesogaea
Oxia Palus
Xanthe
Ascraeus Lacus
Amazonis
Olympus
Mons
Niliacus Lacus
Nilokeras
Tempe
Arcadia
Euxinus Lacus
Mare Acidalium
Baltia
Mare Boreum
Scandia
-60°
-50°
-40°
-30°
-20°
-10°
0°
+10°
+20°
+30°
+40°
+50°
+60°
WEST

Mars 1975-76

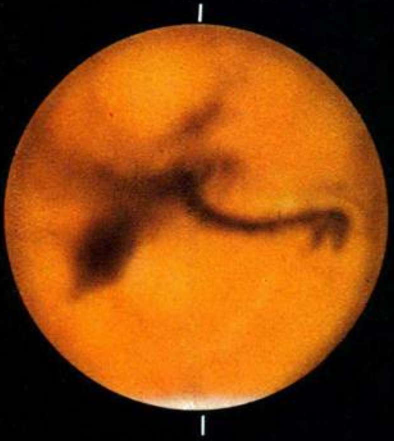
Central Meridian
7:00 p.m. EST

December 5
7:00 p.m. EST



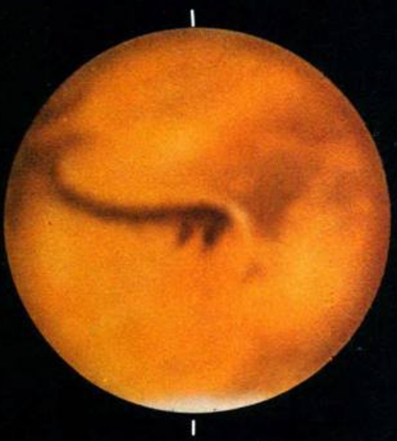
Central Meridian
290°

December 5
9:20 p.m. EST



Central Meridian
325°

December 5
11:45 p.m. EST



Central Meridian
0°

Astronomical telescopes provide "upside down" views of the sky, and the three drawings above show Mars as it would appear. The planet's south pole is at the top. The north polar cap at the bottom will be prominent during this year's opposition. Since the image is inverted, Martian features will move from the right side of the planet to the left. Features at the planet's right limb are experiencing sunrise, while those on the left limb are experiencing sunset. As indicated by the drawings, an observing period of five hours will bring many different features into view. While Mars' rotation is only 37 minutes longer than Earth's, even two hours observation provides enough rotational shift so that Meridiani Sinus is revealed.

The tables below provide statistical information for observing Mars during December 1975 and January 1976, at 7:00 p.m. EST. Date, magnitude and apparent size in seconds of arc are provided in the first three columns. Column four shows what central meridian will be visible at 7:00 p.m. EST, while the last column tells what feature appears in the center of the planet's disk. Compare the degrees of central meridian to the lines of longitude along the top and bottom of the Mars map on the previous two pages. This will help you plan your observing for the evening.

DECEMBER 1975

Date	Mag.	Size	C.M.	Major Feature
1	-1.4	16.4"	327°	Sabaeus Sinus (S)
3	1.4	16.5"	310°	Yaonis Regio (S)
5	1.5	16.5"	292°	Deltoton Sinus (S)
7	1.5	16.6"	275°	Syrtis Major (N)
9	1.5	16.6"	257°	Mare Tyrrhenum (S)
11	1.5	16.5"	240°	Mare Tyrrhenum (S)
13	1.6	16.5"	222°	Gomer Sinus (S)
15	1.5	16.4"	205°	Mare Cimmerium (S)
17	1.5	16.3"	187°	Trivium Charontis (N)
19	1.5	16.2"	169°	Euxinus Lacus (N)
21	1.4	16.1"	152°	Mare Sirenum (S)
23	1.4	15.9"	134°	Olymus Mons (N)
25	1.3	15.7"	117°	Phoenicis Lacus(S)
27	1.3	15.5"	99°	Ascraeus Lacus(N)
29	1.2	15.3"	81°	Tithonius Lacus(S)
31	1.1	15.1"	63°	Corprates (S)

JANUARY 1976

Date	Mag.	Size	C.M.	Major Feature
2	-1.1	14.9"	46°	Aurorae Sinus (S)
4	1.0	14.6"	28°	Mare Acidalium(N)
6	1.0	14.4"	10°	Aram (S)
8	0.9	14.1"	352°	Meridiani Sinus(S)
10	0.8	13.9"	334°	Edom Promontorium (S)
12	0.8	13.6"	316°	Mare Serpentis(S)
14	0.7	13.4"	298°	Syrtis Major (N)
16	0.7	13.1"	280°	Moeris Lacus (N)
18	0.6	12.9"	262°	Syrtis Minor(S)
20	0.5	12.6"	243°	Aethiopis (N)
22	0.5	12.3"	225°	Mare Cimmerium (S)
24	0.4	12.1"	207°	Flysium (W)
26	0.4	11.8"	188°	Phlegra (N)
28	0.3	11.6"	170°	Amazonis (N)
30	0.2	11.4"	152°	Mare Sirenum(S)

"expert" before you actually see Mars through your telescope.

Interestingly, with sufficient magnification on small telescopes, the planet at opposition this month will appear the same apparent size as the moon in the sky without a telescope! At an average distance from Earth of 240,000 miles, the moon subtends an angle of about 1/2 degree in the sky. (This is equivalent to 30 minutes or 1,800 seconds of arc.) Mars' disk will subtend an angle of 16 seconds in December, so 113 power will magnify the planet to the apparent visual size of the moon as it looks in the night sky. (Careful! Most observers overestimate the size of the moon in the sky. This illusion is especially noticeable at the horizon — like the harvest moon which isn't really any larger than at other times of the year.)

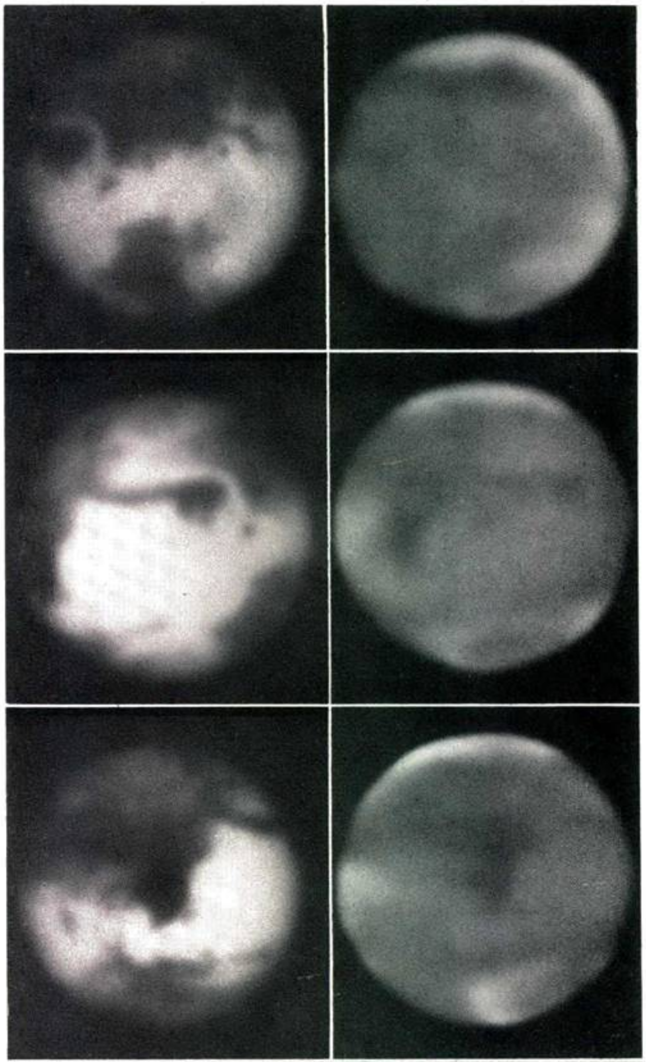
Saintly patience at the telescope is a must if you want to see Martian detail. Critical focus is equally important; you should use the sharp limb of the planet or a nearby star to do so. At high magnification, concentrate at all times on the blurred, trembling image of the planet Those brief moments of fine seeing — moments that offer tantalizing glimpses of the surface of this distant and mysterious world — slip away quickly.

Sharp planetary images require nights of good seeing. Unfortunately, tranquil air is more frequent on warm hazy summer nights than on cold clear winter evenings. If you want the best image on a given night, observe Mars when it's on or near the meridian — the north-south line passing through the zenith. Mars will then be at its highest in the sky; you'll be looking through less atmosphere than when the planet is near the horizon.

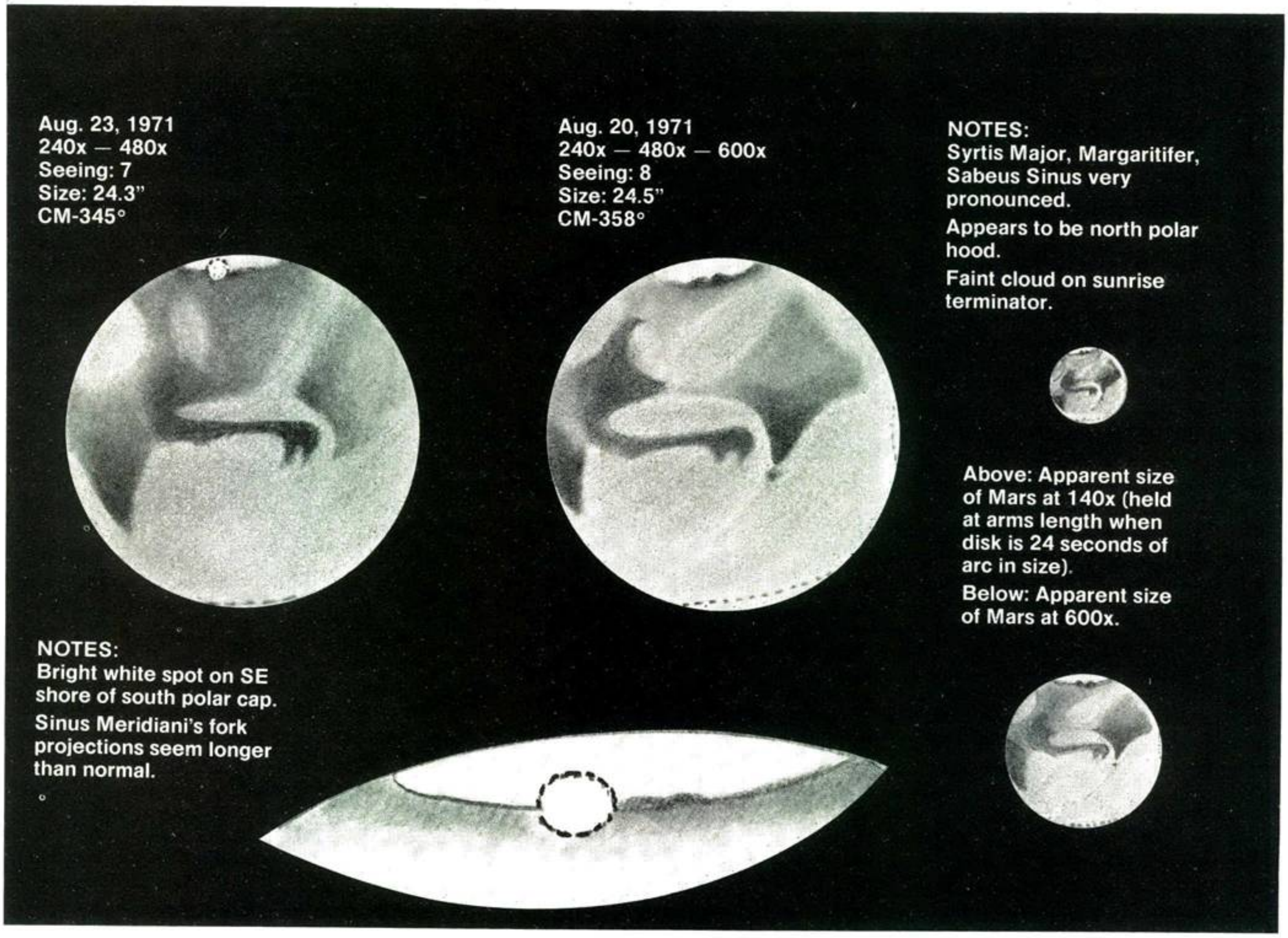
Polar Caps

One of the most striking changes visible on Mars is the gradual growth and recession of the polar caps. These seasonal variations can easily be followed with a six inch telescope, and larger instruments may even reveal a dark *melt band* along the retreating ice border in the Martian springtime.

In the wake of this melt band, higher snow-covered areas can, at times, be seen glistening even after the ground around them has cleared. This effect is only apparent, however. Due to Mars' low



Mars at opposition this year will look very much as it did during its 1969 close approach. The photographs above show a wealth of ever changing detail as the planet rotates on its axis. South is at top as Mars would look in an inverted image telescope. Contrast between light and dark areas, as well as phenomena in Mars' atmosphere can be greatly enhanced by viewing the planet with color filters. The lower photo shows a Meade Instruments photo-visual filter which screws into the threaded end of the eyepiece. The left hand column of Mars photos approximates the visual surface contrast enhancement achieved with a Wratten #25 red filter, while the right column with a Wratten #47b blue filter allows you to see polar clouds and atmospheric haze. (For telescopic apertures of six inches or less, a Wratten #80a medium blue filter is recommended over #47b). Top: Lunar and Planetary Laboratory photographs. Bottom: Meade Instruments photograph.



Aug. 23, 1971
240x — 480x
Seeing: 7
Size: 24.3"
CM-345°

Aug. 20, 1971
240x — 480x — 600x
Seeing: 8
Size: 24.5"
CM-358°

NOTES:
Syrtis Major, Margaritifer, Sabeus Sinus very pronounced.
Appears to be north polar hood.
Faint cloud on sunrise terminator.

Above: Apparent size of Mars at 140x (held at arms length when disk is 24 seconds of arc in size).
Below: Apparent size of Mars at 600x.

NOTES:
Bright white spot on SE shore of south polar cap.
Sinus Meridiani's fork projections seem longer than normal.

Drawings like those above and on the right can be an interesting and rewarding way to record the nightly changes of Martian detail while the planet is at or near opposition. While you certainly won't be able to see all the fine detail shown with a 60mm refractor, apertures of four to eight inches will allow you to see and sketch a wealth of detail. The drawings made with the 13 inch refractor telescope at Allegheny Observatory in Pittsburgh, Penn. are reproduced at the same size as they were sketched during Mars' 1971 close approach. Be sure to make notes as shown above and watch for interesting surface changes like the white spot on Mars' south polar cap "melt" band. Central meridians are provided with each sketch on the right page so you can compare the drawings to the map on pages 52 and 53. Drawings by Robert A. Schmidt.

atmospheric pressure, instead of melting, the ice sublimates (turns directly into gas) — bypassing the liquid state completely.

Mariner probes, together with recent ground based studies, have confirmed our belief that these polar deposits are actually ice. However, we also now know that the Martian ice is a mixture of water and carbon dioxide, or dry ice, rather than the pure water ice we know on Earth.

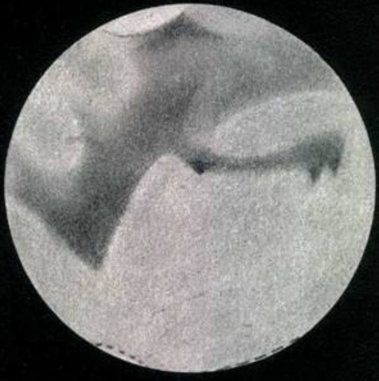
Bright and Dark Regions

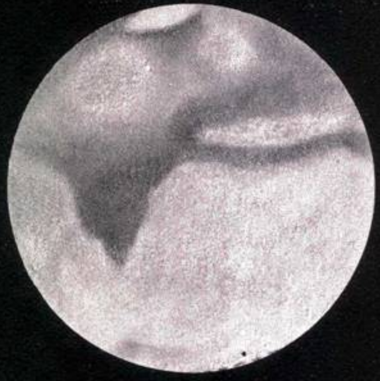
Bright orange areas are vast arid seas of dust and sand, while dark regions — blue-green during Martian summer and dull gray in winter — were long believed to be expanses of vegetation growing and dying in response to the seasons. Mariner photographic results seem to rule out this explanation, but their exact nature remains uncertain. Contrast between bright deserts and dark areas can be enhanced considerably by using an orange or red colored filter; these generally screw into the telescope's eyepiece.

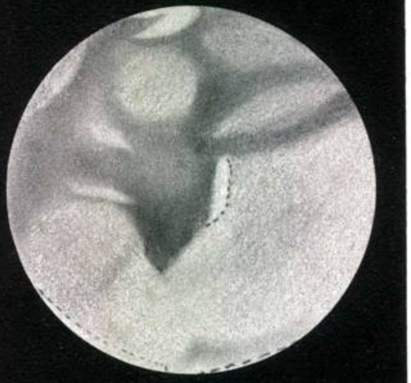
Some dark features exhibit remarkable changes in outline and intensity; one of the most active regions is Solis Lacus. Occasionally these changes are only apparent, caused when dust storms obscure the surface. Others seem to be true physical alterations. An excellent observing project is to monitor active areas nightly if a change appears underway.

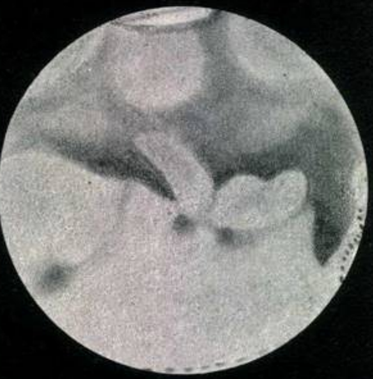
Clouds and Dust Storms

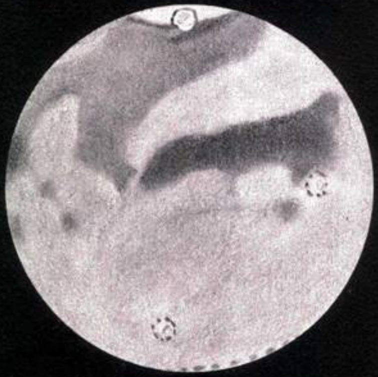
Clouds can be seen suspended high in Mars' atmosphere. White ones, containing ice crystals and vapor, are similar to cirrus clouds on Earth. Observers with a six inch telescope at 200 power should search along the sunrise or sunset terminator (when Mars shows a gibbous phase) or along the planet's limb. Much more obvious are the yellow dust clouds often seen moving across the deserts and into the dark areas, obscuring large surface areas. These are intense dust storms driven on occasion to global fury by high velocity winds. (The most recent global dust storm occurred in 1971 as Mariner 9 arrived for its photographic mission.) To enhance visibility of Mars' clouds, use a green or blue eyepiece filter.

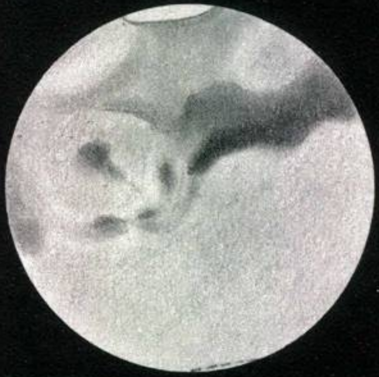

July 18
CM-327°

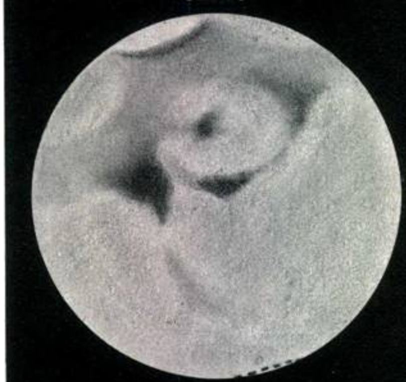

July 21
CM-304°

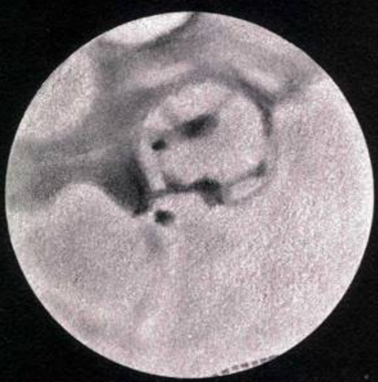

July 22
CM-290°

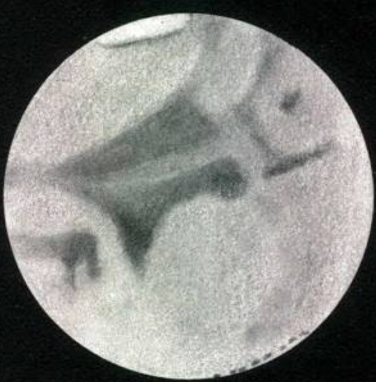

July 28
CM-244°

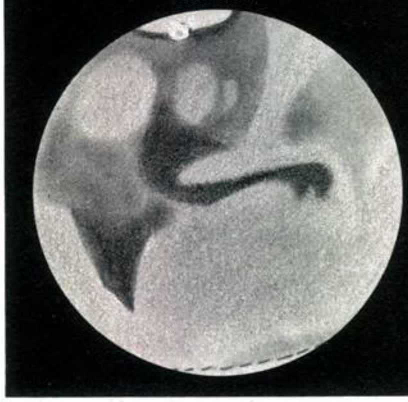

Aug. 8
CM-141°

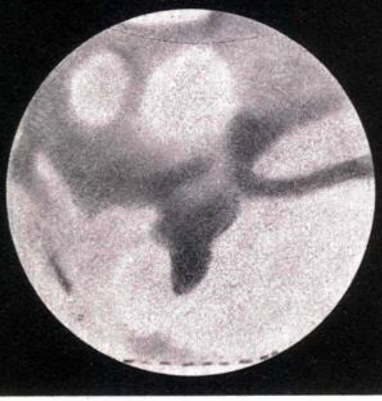

Aug. 9
CM-113°

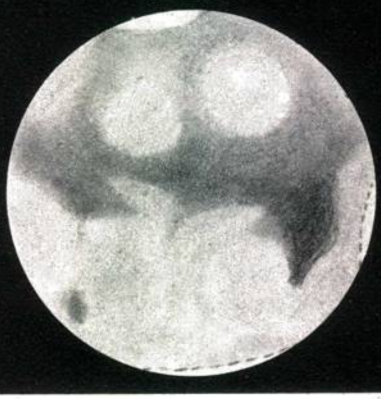

Aug. 11
CM-85°

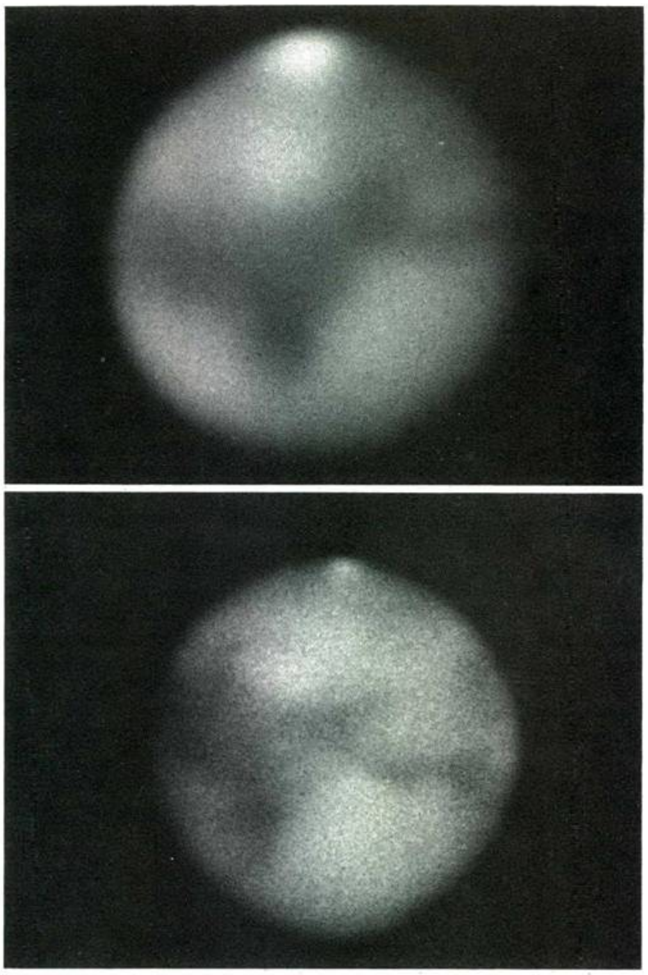

Aug. 13
CM-78°


Aug. 16
CM-41°


Aug. 24
CM-332°


Aug. 29
CM-292°


Aug. 30
CM-268°



Home built eight inch Newtonian reflector telescopes captured the planet Mars during two past oppositions. The upper photograph, a seven second exposure on Kodak Verichrome Pan film, was made using eyepiece projection with an effective focal ratio of f/133. Syrtis Major is featured prominently on Mars' central meridian in this Aug. 26, 1971 photo. While the Martian south polar cap was very bright in this photo, it was only a small white spot during its next opposition two years later as shown in the lower photograph. Eyepiece projection was again used — this time on High Contrast Copy film exposed for five seconds — with an effective focal ratio of f/105. Note Mars' gibbous phasing. This effect grows more apparent as the planet moves away from us after opposition. In this picture, it's midafternoon on Syrtis Major — while on Meridiani Sinus it is early morning. Upper: Photograph by Howard Zeh. Lower: Photograph by James K. Rouse.

Canals

Mars' famed canals have fired the imagination since their discovery by Schiaparelli in 1877. Countless visual observers faithfully charted a vast network of interconnecting lines giving rise to the fanciful belief that they were an artificial irrigation system constructed by the inhabitants of Mars.

Mariner probes have destroyed this concept, showing the canals to be only a chance alignment of dark spots, crater chains and valleys. A space age fact that removes some of the mystery and romance surrounding Mars? Perhaps so — yet the optical illusion remains. As a sophisticated observer of the mid-1970s, take pride in the knowledge that somewhere near the elusive limits of resolution, that canal you see may include the volcano Olympus Mons or the great canyonlands of Mars.

Unusual Activity

One of the most exciting aspects of Mars observing is the possibility of being able to witness something happening on or near the planet. Many reports of strange occurrences — flashes of light, flares, unusual clouds — have been made by highly qualified and experienced observers. In one case, Japanese observer Tsuneo Saheki recorded a strange flare over Tithonius Lacus and a cloud near Edom Promontorium that changed color much like a chameleon. In another instance, American observer and space expert Clark McClelland witnessed a bright cloud billowing from the edge of the planet — an event confirmed by a Russion observation at precisely the same time.

Once thought to be reflections of the sun from bodies of water on Mars, scientists currently attribute these events to residual volcanic activity.

Recording Mars

Direct photography is an excellent method of recording Mars' features at opposition for those equipped with large and stable instruments. But direct visual observation remains the best way to see the finest detail; you may wish to record this detail by carefully sketching what you see while at the telescope.

Start with a two inch disk drawn in pencil on white cardboard. As you observe, carefully plot the features you see; draw them as accurately as possible with close regard to their shapes and positions.

Notes added to your drawing can indicate color and brightness of Martian features. Use an arbitrary scale from 1 to 10, with 1 representing the darkest features and 10 the lightest. For example, 10 would correspond to the sky background, while 1 would represent the polar cap.

The use of pastel pencils is not generally recommended by experienced observers, since attention is often given to producing a pretty picture rather than an accurate drawing. Nevertheless, color renditions do have great esthetic appeal.

Advanced observers who make extremely detailed drawings may wish to submit them to the Association of Lunary and Planetary Observers, ALPO Director Professor Walter H. Haas, Box 3AZ, University Park, N.M. 88003.

Please note day, time, sky conditions, telescope (brand name), magnification used and observing location. Above all, don't forget to include your name and address with all drawings.

If you photograph or sketch Mars this month, how about submitting your results to ASTRONOMY too? We may be able to use your drawings or photos in future installments of Sky Almanac. Payment for their use is $10 in color and $7.50 in black and white.

PUBLISHER'S MEMO

The October issue of ASTRONOMY carried an Equipment Atlas article by Thomas Cave, president of Cave Optical Co., and James Mullaney, one of our consulting editors. The article — "Buyers' Guide to Telescopes" — has been enthusiastically received by readers so we will do more articles like this in the future.

When we make a mistake — like it or not — we feel compelled to admit it for the good of our readers. Lord knows how we did it, but we left out **The Optical Craftsman** from the table of Newtonian telescope manufacturers in the "Buyers' Guide" article. So to set things straight, their address is The Optical Craftsman, Inc., 20962 Itasca St., Customer Service Dept. AM-11, Chatsworth, Calif. 91311. This company's brochure costs 20¢ (in stamps, so it's basically for postage), and your request brings you a free descriptive catalog of Messier deep sky objects. Their eight inch aperture "Discoverer" — a Newtonian reflector telescope — sells for $555 and includes clock drive and setting circles. Sorry about the oversight, and many thanks to the readers who pointed out the omission to us.

It would be great if everyone was as happy with the "Buyers' Guide" as readers were. Unfortunately, such is not the case as has been abundantly pointed out by adverse reaction from telescope manufacturers and advertisers. So, as a prelude to further discussion on this we'd like to let you in on our formal — though hitherto unpublished — policy with regard to advertising vs. reader service.

Before we started ASTRONOMY we decided that if circulation revenue alone (subscription dollars) could not support the continued success or eventual profitability of the magazine, ASTRONOMY would not be published. Many magazines depend heavily on revenue from advertising in order to keep publishing, and we decided very early that this would be impossible for ASTRONOMY. Why? Two reasons.

First, in the past publishers greatly undervalued the worth of their magazines to readers. Their reasoning was based on the concept of selling huge masses of people inexpensive subscriptions. With a mass circulation the magazine would attract many more advertisers and the publishers could charge higher and higher advertising rates as the circulation grew still larger.

Well, television changed all that; advertisers discovered that they could reach many more people less expensively by bringing their products to the tube. As a consequence, the primary source of publishing dollars for mass circulation general interest magazines — advertising revenue — gradually, mercilessly, dwindled from a gush to a trickle. What did these magazines have left? Too few dollars from faithful subscribers to continue publishing—*requiescant in pace* **LIFE**, **LOOK**, etc.

The second reason why we didn't want to depend on advertising revenue to majoritively support ASTRONOMY was very simple: The 1973 astronomy market was small and ill-defined. Our prepublication market studies showed that prior to 1973 there was a definable readership universe of 500,000 people. Approximately 1/2 to 3/4 of this group overtly supported 10 or so major consumer level astronomy product manufacturers and fewer than 100 medium to very small astronomy service/product companies. Obviously, it was impossible to seriously believe that so few manufacturers as advertisers could offer reasonable revenue support to our publishing venture — at least at the outset. (Incidentally, that half million readership universe has grown considerably since ASTRONOMY entered the market. Furthermore, refined marketing methods have allowed us to more clearly define our readership universe with current estimates expanded to about 2,000,000 people.)

Thus, ASTRONOMY would have to be a reader service oriented magazine in order to survive. And this basic philosophy influenced other policies we've never told you about.

While publishing industry practice expands or contracts a magazine's page total by virtue of the number of advertising pages in a given issue, ASTRONOMY would aim for a magazine size of 80 pages based on levels of paid circulation. (This base circulation level was reached with our January 1975 issue and ASTRONOMY has been 80 pages ever since.)

We determined that the most advertising that could be expected from the advertiser market would be 22 pages total. At this peak advertising level, and based on ASTRONOMY's higher than normal rates, advertisers could only contribute a maximum of 25 percent toward the magazine's total circulation/advertising revenue pie. Therefore, once ASTRONOMY's 80 page base was reached we would accept a maximum of 22 pages of advertising before proportionately increasing the number of magazine pages. (We would like to point out that many magazines balance 55 to 65 percent articles and editorial matter with 45 or 35 percent advertising. ASTRONOMY's ratio — at a maximum of 22 advertising pages — would be 72.5 percent editorial to 27.5 percent advertising.)

So now you have it — the maximum we might expect from advertisers, and the policies that express our continuing philosophy toward advertising in ASTRONOMY. In the beginning we considered the idea of not having advertising in the magazine at all. But if we had declined on this point entirely we would have failed to provide you one of the services you want most from ASTRONOMY — to be informed by way of advertising on where you can buy telescopes and other astronomy related products or services. And in our first months your letters requesting more advertising in the magazine proved this to be the case. Final proof came with our readership survey in December 1974 — 87.5 percent told us they were either satisfied with advertising in ASTRONOMY or wanted us to publish more.

Advertising is here to stay. But our philosophy remains unchanged — you readers want and need ASTRONOMY and we are here to serve you first. If and when advertising contributes 25 percent to our publishing revenue, that'll be great! It will be frosting on the cake to help us give you an even better magazine. We know where loyalties are however, and as long as you want and need us we could continue to publish ASTRONOMY even if we had no advertising.

Just for the record, during the last 12 months advertising revenue only contributed slightly more than 1/3 the maximum we expect. From the circulation/advertising revenue pie, advertising represented an 8.5 percent sliver.

Which brings us full circle to the reason for this lengthy memo. "Buyers' Guide to Telescopes" generated across the board dissatisfaction with the way we handled the article from almost every major manufacturer representing each type of telescope we discussed. The article talked about refractors, reflectors and catadioptric telescopes. While completely geared to the neophyte enthusiast on his first telescope buying expedition, the article was importantly geared toward this group's parents who don't know anything about telescopes, to keep them from buying their youngsters a toy or useless instrument that would only frustrate and discourage budding interest in astronomy. We didn't even judgementally review the merits of any given manufacturer's telescopes.

In days gone by, when I was in public relations, if one of my clients got publicity like these telescope manufacturers did in a key industry publication without my having to do a lick of persuasion to get the publicity, both my clients and I would have jumped for joy and showered the publisher with hugs and kisses.

Well, telescope manufacturers must be a different breed because that's not the response we got from them. Apparently they're either starved for publicity and when they get it don't know how to react, or we're doing our reporting job right and they fear you'll discover something they don't want you to know.

Frankly, we don't want to believe that. We don't even want to believe that the petty criticism we've been showered with lately is symptomatic of the industry's small size.

Nevertheless, here's a letter received from **Unitron Scientific** that typifies advertiser response:

Dear Mr. Walther:

We wish to extend our compliments to Thomas Cave and James Mullaney for their fine article, "Buyers' Guide to Telescopes", under your section "Equipment Atlas" appearing in the October 1975 issue of ASTRONOMY.

We do, however, take exception to two or three misleading statements made in this article concerning **Unitron** refractors. For example, on page 60, under the heading "Where Available", it is stated "mail order only". This is not true. **Unitron** refractors have been available for many years from our dealers, as well as from **Unitron** direct. Currently, **Unitron** refractors are sold throughout the United States and Canada by 40 dealers. We are concerned naturally with the effect that this statement may have on the sales of **Unitron** refractors.

On the same page, under the heading "Delivery", an all-inclusive statement of "2 to 6 months" is made. Of course, it is true that like other manufacturers of telescopes, there have been occasions when backorder situations have occurred for a specific model or models due to an unexpected increase in orders. But this is definitely not true for all **Unitron** refractors as intimated in this article.

We also find with the generalized statement found at the top of page 64

Counter Sales

Bookstores, magazine counters, planetariums, museums, libraries and astronomy clubs across the country are finding a new money-making opportunity with ASTRONOMY Magazine.

ASTRONOMY's cover price is $1.50, but if you place a standing order monthly to purchase five or more copies of each issue for resale you only pay $1.00 per copy. You make 50¢ on each copy of ASTRONOMY.

Astronomy clubs may take advantage of this too since many members who don't subscribe may want to purchase a single copy at meetings. In addition, if your club gives public lectures or has open house nights you have an excellent opportunity to pad your organization's treasury with extra cash from ASTRONOMY sales.

Orders are accepted from all established places of business, libraries, museums, planetariums and recognized science or astronomy clubs or organizations. Bills are mailed the same day bulk orders are shipped and are payable in 30 days.

Individuals may also act as resale agents but payment must accompany orders until credit is established.

Bulk copies are sold on a nonreturnable basis, so make your first order a conservative one and increase the quantity later when you establish your level of sales. Sales supportive materials, such as counter cards, banners, etc., may be available at cost depending on the volume of demand.

For more information write: Nancy Faustmann Bulk Copy Sales ASTRONOMY Magazine
757 N. Broadway, Suite 204 Milwaukee, WI 53202

"That the price of a 4 inch refractor is 15 times greater than a 2.4 inch instrument". This again is not true, and therefore this type of statement would, of course, discourage purchases of larger refractors. **Unitron** offers various telescope models in each aperture. One 2.4 inch altazimuth model sells for $289, while a 4 inch altazimuth model is priced at $744. This price is usually about 2-1/2 times as great as the 2.4 inch **Unitron**.

We would expect that a copy of this letter will be included in the "Letters to the Editor" column in the next issue of ASTRONOMY. Also, copies of this letter are being forwarded to both Thomas Cave and James Mullaney.

We think ASTRONOMY is an excellent publication. This is why we chose to place a full page ad in the November issue. Hopefully, the article that we are discussing will not nullify the effects of our November advertisement.

I would strongly recommend that on future similar articles, your writers take the trouble to check with your advertisers in advance of publication in order to bring your readers the information which "by its accuracy" will be most valuable.

Cordially yours,
Jerry Dill
UNITRON SCIENTIFIC, INC.

Well, Mr. Dill, regarding your first two points, preliminary editorial research on "Buyers' Guide to Telescopes" included telephone interviews with someone at each telescope supplier /manufacturer listed in the tabular guides.

Naturally, we wanted to report both accurate *and* unbiased information — especially on delivery. To do this our editors did not identify themselves as ASTRONOMY employees when they phoned, so they would sound like interested potential customers. Two of the questions our editors asked were: "Do you sell your telescopes primarily by mail order, or do you also sell them through major, regional or national chain stores and dealers?", and "What is the realistic delivery time for your telescopes during the Christmas rush?".

Answers to these two questions, as published in the article, were provided by the **Unitron** representative our editors interviewed. Therefore, any inaccuracies stem from a misinformed **Unitron** employee.

As to an "unexpected increase in orders": Do you mean to say that **Unitron** has never had a Christmas rush before — that your company has somehow remained immune to the crazy rush of last minute gift buyers so typical of every other industry?

The majority of reader complaints we receive about advertisers concern delays in delivery of their telescopes. Many of ASTRONOMY's readers, young and new to astronomy as a hobby, do not realize that a quality optical instrument takes care and *time* to manufacture, and that good telescopes may not necessarily be shelf items like stereo equipment. As a courtesy to advertisers and readers alike we have intermediated delivery complaints with diplomacy because we comprehend both neophyte reader impatience and advertiser desire for quality product manufacturing. We tell readers this and ask them to "hang in there" a while longer — that back-order situations may mean their telescope might not be delivered for a total of 8 to 10 months.

And the amazing thing is, the majority of readers write back to thank us saying they're satisfied just knowing how long it'll take. They don't like to wait so long, true — but most don't want to cancel their orders either.

"A four inch instrument... has 65 percent greater resolving power than a 2.4 inch, but its price may be 15 times as great." This is the exact quote you refer to regarding refractors — and

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★ Accustar is used by observatories, universities, and astronomers throughout the world.

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State Zip

you're absolutely right: The statement is false. Using the price ranges found in the tables with that article a four inch refractor could actually cost as much as *33 times more* than a 2.4 inch. But so what? We also talked about bare bones minimums and gadget fat maximums, and even a totally inexperienced reader realizes — as pointed out in the article — that larger aperture and more accessories like clock drive and equatorial mount will boost the aperture price spread vastly. And that's why we said "may be 15 times as great".

We seriously doubt that any comparison of prices alone would discourage upper-intermediate or advanced level astronomy enthusiasts from the purchase of a large aperture refractor. We are all well aware of the fact that as an enthusiast learns more about visual astronomy he tends to specialize his viewing interests. If his viewing specialization is serious planetary observation — as in the past — he will gravitate toward a large refractor because refractors provide sharpest images with best definition for this kind of study.

In short, we regret that you "expect" us to publicly air your complaints as though doing so were an important contingency to your continued advertising in ASTRONOMY. Granted, you "chose" ASTRONOMY as an advertising medium — and it's about time, I might add — not just because it's a beautiful magazine but because ASTRONOMY's readers represent a profitable market for **Unitron** refractors.

It is on this point alone — the power and value of ASTRONOMY as a sales medium for **Unitron** — that you should base your decision to continue or withdraw advertising. As for ASTRONOMY, we accept **Unitron** as an advertiser because your company is noted for good customer service and quality instruments, and publishing your ads helps to inform our readership. This is and will continue to be the basis upon which we will accept advertising from **Unitron**.

Sincerely,

Stephen A. Walther

Stephen A. Walther
Publisher

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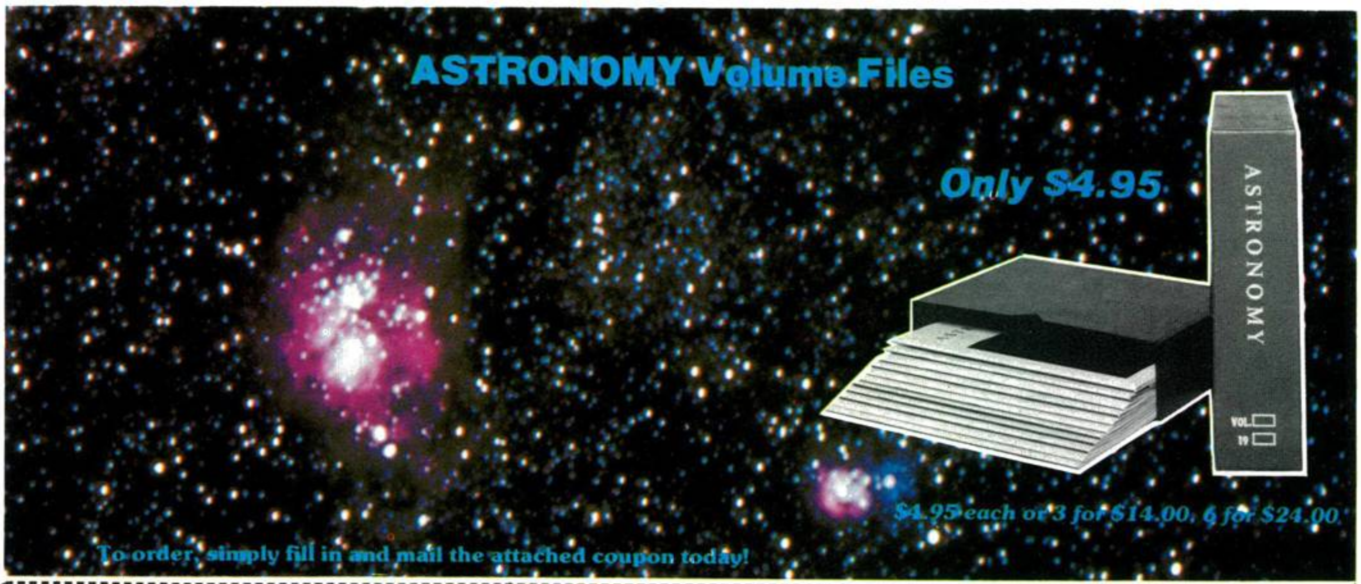
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continued from page 33

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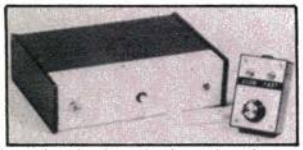

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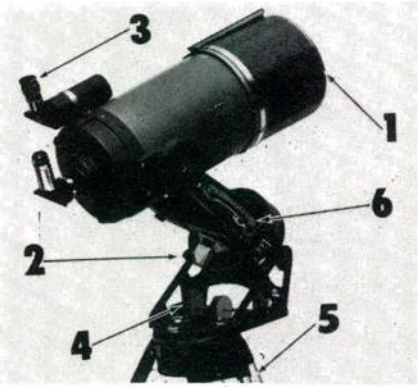

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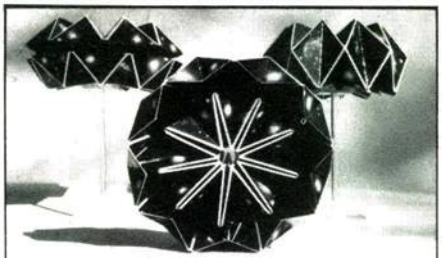

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ASTRONOMY

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Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. The following back issues are depleted: September, October, November, December 1973; January, February, August, December 1974; and April 1975.

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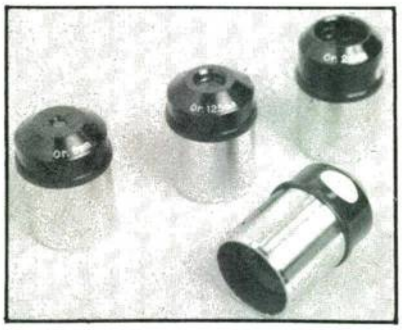

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STAR DOME

DECEMBER

by

James Mullaney

Astronomy enthusiasts who want to learn the constellations with greater ease can make their efforts more interesting by studying the distinctive geometrical shapes characterizing each season's sky. Spring is marked by a diamond, summer by a triangle, fall by a square and winter, a circle.

Mid-December evenings (at about 8 p.m. Local Standard Time) provide an excellent opportunity for viewing at least three of these four figures simultaneously!

Just above the northwestern horizon are three blue-white beacons marking the Summer Triangle. These are Vega in Lyra the harp, Deneb in Cygnus the swan or Northern Cross, and Altair in Aquila the eagle. Increased atmospheric absorption and pollution near the horizon make these stars less spectacular than during late summer evenings when overhead, but they are still unmistakable celestial markers.

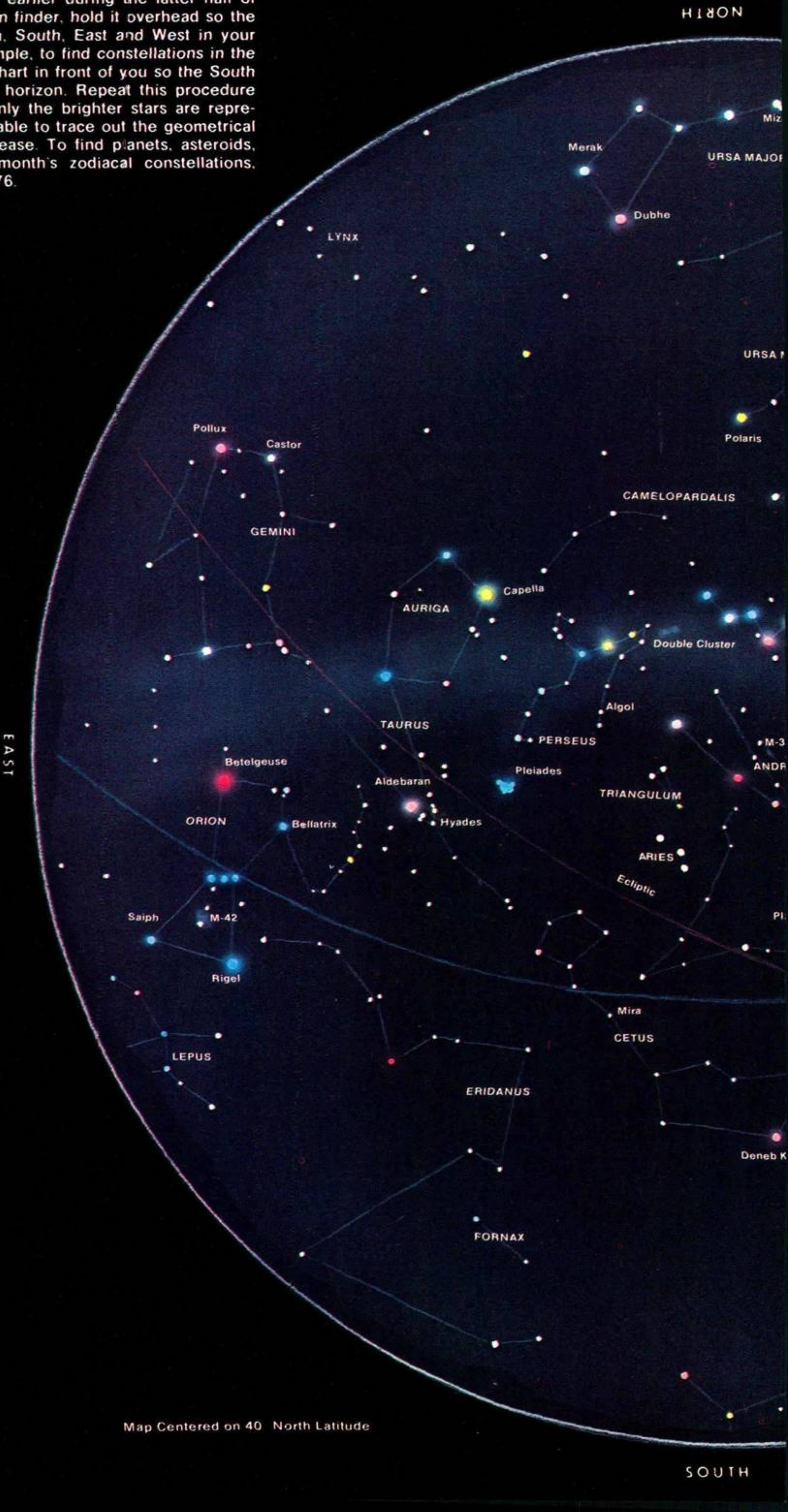
Olcott, in his classic observing guide **Field Book of the Skies**, says Cygnus is actually seen best in winter, as the swan then stands upright over the western horizon. He continues, "On Christmas Eve, at 9:00, it stands outlined against the western sky, a starry symbol of the Christian faith, a sign of hope from the realm beyond."

Second of the three geometrical shapes to be seen in the winter sky is a large square, whose corners are marked by the stars Alpha, Beta and Gamma Pegasi and Alpha Andromedae. When facing south, this figure is situated high in the sky just west of the meridian. Within its huge confines is a stellar desert containing little that is visible to the unaided eye. The Great Square of Pegasus is really a distorted rectangle, as the monthly Star Dome map shows.

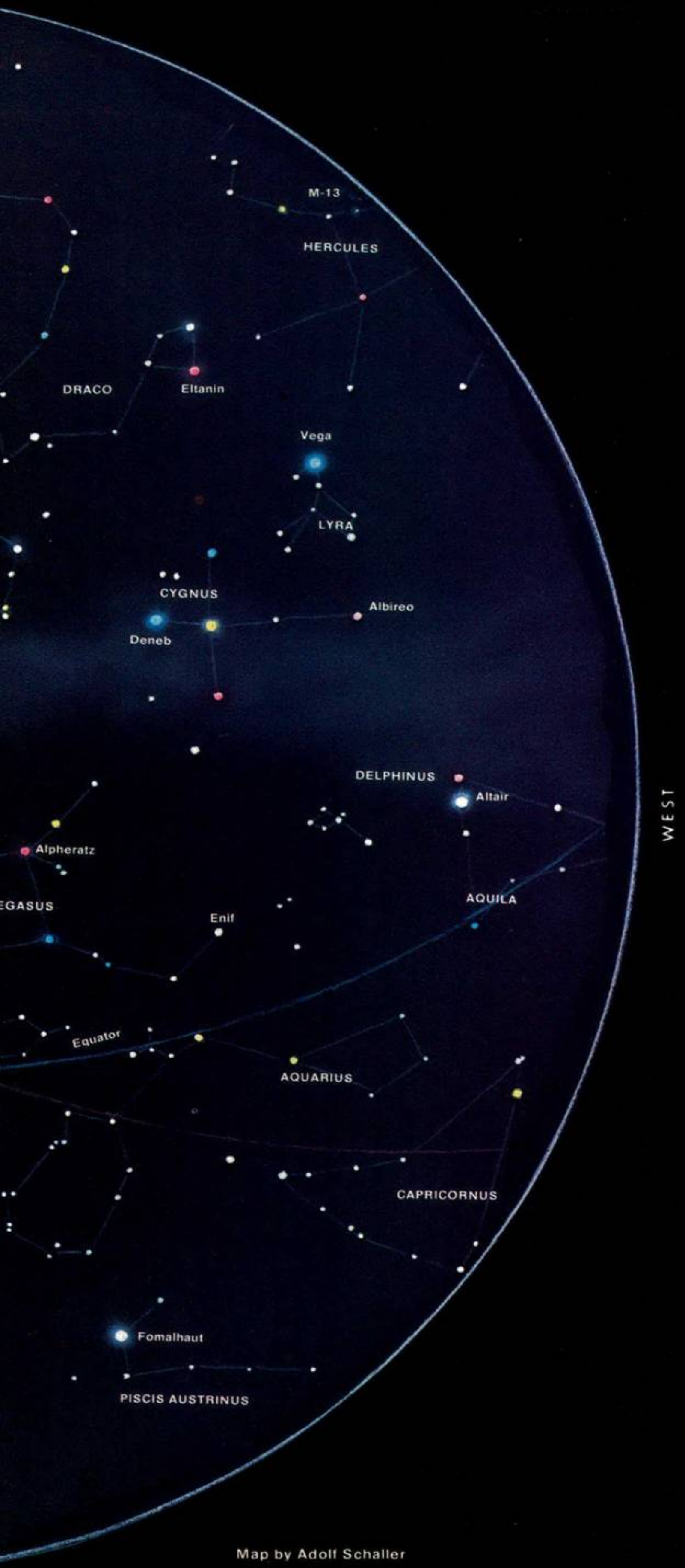
The only bright winter star not included in the geometrical figures is first magnitude Fomalhaut. This blue-white luminary in the constellation Pisces Austrinus (the southern fish) hangs low over the southwestern horizon. If you draw a line from Beta through Alpha Pegasi in the right side of the square and extend it downward, it points directly at this solitary monarch.

The third geometrical form is a circle of seven glittering first magnitude stars commanding attention in the eastern sky. Beginning with Capella in Auriga, this rough circlet includes Castor and Pollux in Gemini, Procyon in Canis Minor, Sirius in Canis Major, Rigel in Orion, Aldebaran in Taurus and Capella to close the circle. Near the center of this

This Star Dome rendering approximates the sky as it appears at about 8 p.m. Local Standard Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.


NORTH
Miz
Merak
URSA MAJO
Dubhe
LYNX
URSA M
Polaris
Pollux
Castor
CAMELOPARDALIS
GEMINI
Capella
AURIGA
Double Cluster
Algol
TAURUS
PERSEUS
M-3
ANDR
EAST
Betelgeuse
Pleiades
Aldebaran
TRIANGULUM
ORION
Bellatrix
Hyades
ARIES
Ecliptic
Saiph
M-42
Pl
Rigel
Mira
CETUS
LEPUS
ERIDANUS
Deneb K
FORNAX
SOUTH

Map Centered on 40 North Latitude



Map by Adolf Schaller

celestial campfire lies a glowing red ember — an additional first magnitude sun — Betelgeuse in Orion. Thus the winter circle contains eight of the brightest stars in the heavens — truly a spectacular scene!

Once you've located each of the bright stars in the season's large geometrical shape, it's easy to locate the remaining stars of each constellation by comparing the sky to the Star Dome map. Finally, when seeking constellation outlines, connect the stars with lines to form shapes, figures and patterns that are easy for you to remember. The ancients populated the sky with things like a charioteer (Auriga), little dog (Canis Minor) and a king (Cepheus) in minute detail, and to them the constellations looked like their namesakes. However, the ancients didn't have things like light pollution to interfere with their view of the sky.

As a result, today it may be easier for you to learn the constellation names and merely associate these names with your own shapes. Thus, Auriga becomes pentagon, Canis Minor becomes bright star-tipped line, and Cepheus becomes lopsided house.

Close-Up on the Aries/Pleiades Region

While discussing the sky's bright, first magnitude stars, let's not ignore the splendor of the many lesser luminaries. Three prominent stars form the triangular figure of Aries the ram; Alpha (α), Beta (β) and Gamma (γ) Arietis are second, third and fourth magnitudes respectively. Together with nearby fifth magnitude Lambda (λ), these stars provide an excellent sequence for those wishing to compare stellar brightnesses.

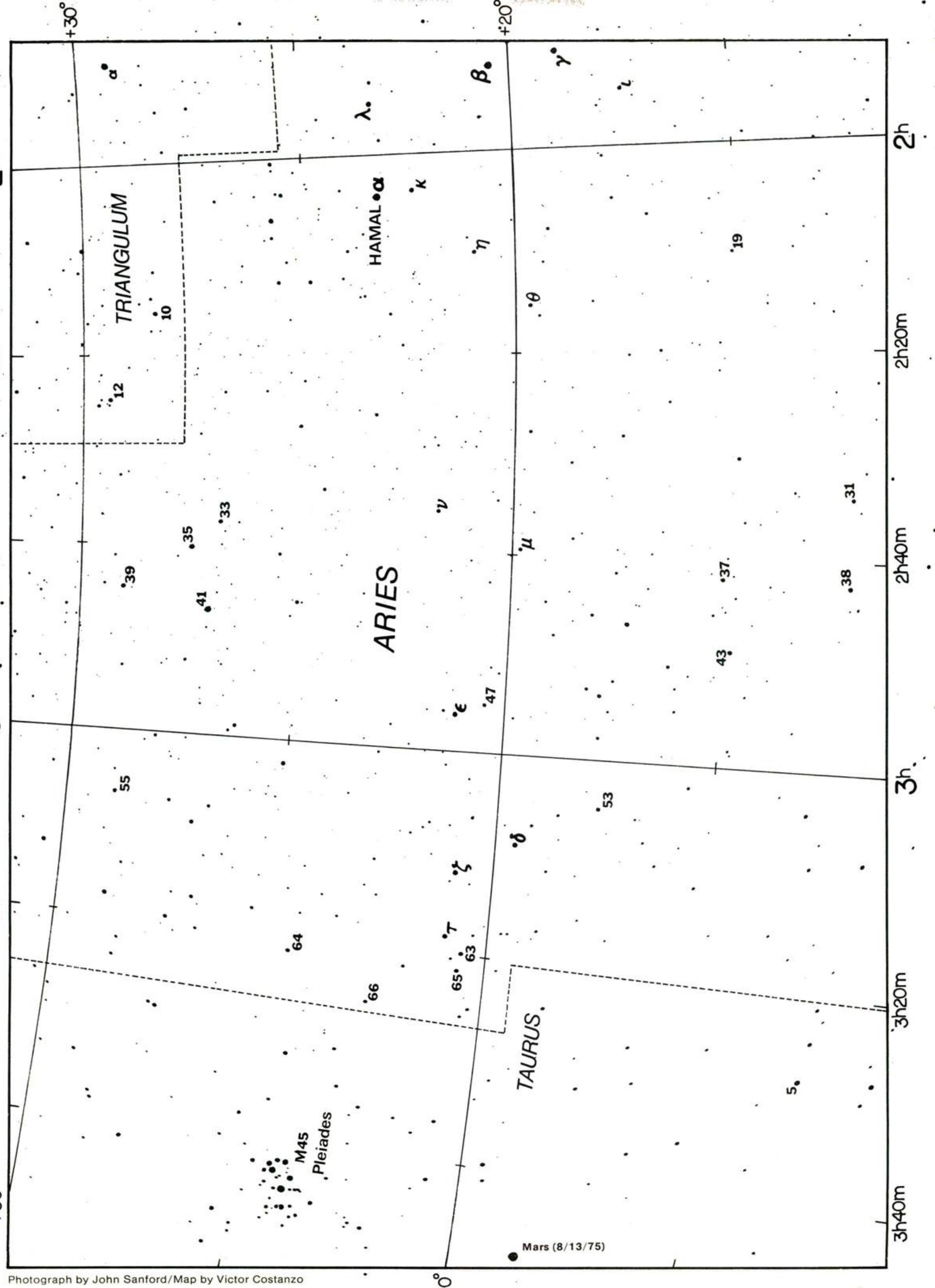
Aries marked the position of the vernal equinox 2,000 years ago. At that time the sun, in its journey along the ecliptic, crossed the celestial equator within the borders of this constellation marking the first day of spring. Today, due to the slow wobbling motion of Earth's axis, this point has now shifted — or precessed — westward to the neighboring constellation Pisces, and Aries hosts the sun a month later than it once did.

This sky area also contains another striking open cluster of stars visible to the unaided eye. The famous Hyades cluster will be highlighted in next month's Star Dome.

Eyepiece Impressions

M-45 — The Pleiades

Bright and dazzling, the Pleiades star cluster highlights December's region of the winter sky.


+30°
+20°
2h
2h20m
2h40m
3h
3h20m
3h40m
+30
TRIANGULUM
ARIES
TAURUS
HAMAL
α
β
γ
λ
ι
κ
η
θ
ν
μ
ε
δ
ζ
τ
10
12
19
31
33
35
37
38
39
41
43
47
53
55
63
64
65
66
5
M45
Pleiades
Mars (8/13/75)

Photograph by John Sanford/Map by Victor Costanzo

Inspiring poets and scientists alike, this open cluster is boldly visible to all who look skyward.

The Pleiades — also known as M-45 — is a gathering of young, hot, blue-white stars that mark the right shoulder of Taurus the bull, northeast of Aldebaran and the Hyades. Draw a line upward through Orion's three belt stars and you will find the Pleiades. With an apparent angular size of 100 to 120 minutes of arc — nearly four full moon diameters — and the combined light value of a first magnitude star, it is difficult to miss.

Nearsighted readers might want to view the Pleiades without their glasses, comparing the brightness of its blur with the matching blur of light from nearby stars such as Bellatrix in Orion (1.7 magnitude), Castor (1.6) or Pollux (1.2) in Gemini. By blurring a star — a point source of light at a known magnitude — and comparing the blur to an extended object such as the Pleiades, a comet or nebula, you can visually estimate the approximate magnitude of the extended object. Orange colored Aldebaran (1.1) and ruddy Betelgeuse (0.4-1.3) can also be used for the Pleiades comparison, but their hues make it less obvious since the Pleiades are bluish in color.

You can see more than 100 stars in M-45 with a small telescope and as many as 500 down to 14th magnitude in large instruments. Photography reveals that several thousand stars are associated with this cluster. Sharing common motion through space, these stars appear to be converging on a point in the sky about five degrees east of Betelgeuse in Orion — a perspective effect similar to a meteor shower in reverse. Due to the cluster's distance from Earth (410 light-years), this motion is so slight that it will take the Pleiades 50 centuries to move the diameter of the moon across the sky!

Generally considered the most famous of all open clusters, many observers rate M-45 as the finest representative of its class. It has great visual appeal — especially in finders, binoculars and rich-field telescopes in spite of the fact that Harlow Shapley catalogued it as "loose and irregular". Olcott mentions its "charming appearance" in field glasses and others have referred to it as a naked eye wonder.

How many stars can be seen in the Pleiades without optical aid? On dark nights six stars are obvious to most with occasional glipses of others. The brightest member is Alcyone [or Eta (η) Tauri] at third magnitude, followed by fourth and fifth magnitude stars among which are Atlas, Merope, Electra, Maia, Taygeta, Calaeno, Pleione and Asterope.

Some keen-eyed observers have been able to count as many as 14 stars in the group and even more are on record. On dark moonless nights when air is transparent, seeing good, and your eyes are well dark adapted, search the Pleiades with averted vision to see if you can beat the record. A sketch of the stars you see should be checked with binoculars or a photograph for confirmation — but only after the observing session has been completed, to avoid bias.

Apparently at some time in the distant past there were seven stars easily visible to the eye, resulting in the cluster's well-known nickname, the Seven Sisters. The legend of the "Lost Pleiad" is nearly universal in all cultures, and — like many legends — it may indeed have some basis in fact. Interestingly, a vast amount of folklore has arisen to account for the missing star.

The peculiar spectrum of Pleione has led scientists to speculate that this star once shone with temporary brilliance and is the lost sister. Although the possibility seems remote, Pleione may someday again flare up. So be alert — the Lost Pleiad may yet return!

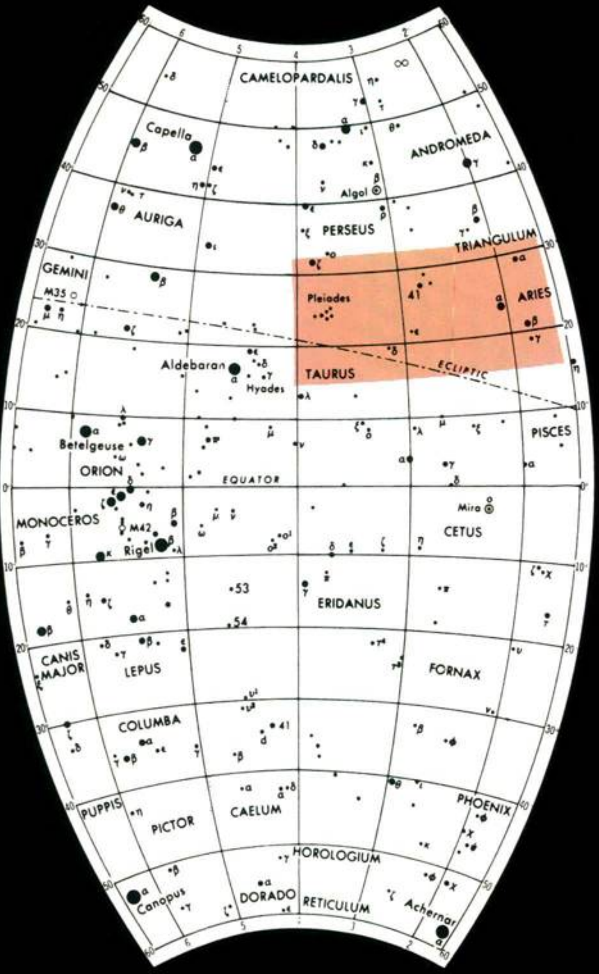
A real showpiece in binoculars, many observers find M-45 a telescopic disappointment. Generally it is too large to fit entirely within the field of most eyepieces, even at low magnification. This difference in sky coverage between binoculars and telescopes is shown in the two drawings.

Despite its size, the Pleiades has much to offer the telescope user. Webb, for example, calls our attention to "...a beautiful triangle of small stars that will be found near... Alcyone" and mentions the "remarkable absence of color in the group, except in one minute ruddy star...."Both features, seen in the six inch reflector view at 50 power, are easily visible in a three inch refractor at 45 power. The rose colored star lies near the apparent center of the group and forms an attractive double star with a blue-white member.

Barns describes the Pleiades stars as "B-type giants, blue-white, gold and violet... involved in far-reaching nebulosity". Indeed, most of the Pleiades have a distinct bluish cast revealing their high surface temperatures. But here and there, minute orange and red suns can be seen — especially in eight inch and larger telescopes.

Nebulosity mentioned by Barns is often seen in time exposure photographs of the cluster, appearing much like mist around mercury vapor street lights on a foggy night. Visually, however, it is a real challenge to detect. The brightest part of this elusive stellar mist — designated NGC-1435 — surrounds the star Merope and was discovered visually in 1859 by Tempel. Webb describes it as "...a faint extended, somewhat triangular haze, involving, at its north extremity, Merope, the bright star south preceding (southwest) of Alcyone." Webb's notes also indicate that he saw the nebulosity with telescopic apertures of less than two inches, and that it was invisible with an 11 inch. He attributed this apparent discrepancy to a loss of contrast in a narrower field of view.

As with other faint subjects — the North America nebula in Cygnus and the Horsehead in Orion — telescope size has less to do with seeing NGC-1435 than training of the eye and sky condi-


CAMELOPARDALIS
Capella
AURIGA
ANDROMEDA
Algol
PERSEUS
TRIANGULUM
GEMINI
M35
Pleiades
ARIES
ECLIPTIC
Aldebaran
Hyades
TAURUS
PISCES
Betelgeuse
ORION
EQUATOR
MONOCEROS
M42
Rigel
Mira
CETUS
ERIDANUS
CANIS MAJOR
LEPUS
FORNAX
COLUMBA
PUPPIS
PICTOR
CAELUM
PHOENIX
HOROLOGIUM
Canopus
DORADO
RETICULUM
Achernar

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

α	**Alpha**	η	**Eta**	ν	**Nu**	τ	**Tau**
β	**Beta**	θ	**Theta**	ξ	**Xi**	υ	**Upsilon**
γ	**Gamma**	ι	**Iota**	ο	**Omicron**	ϕ	**Phi**
δ	**Delta**	κ	**Kappa**	π	**Pi**	χ	**Chi**
ϵ	**Epsilon**	λ	**Lambda**	ρ	**Rho**	ψ	**Psi**
ζ	**Zeta**	μ	**Mu**	σ	**Sigma**	ω	**Omega**

Map from **Guideposts to the Stars**; reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

Close-Up on Selected Objects

Object	Type	Mag.	Size/ Sep.	R.A. (1950)	Dec.
ARIES					
1 Arietis	★2	6.3/7.4	3"	1^h47^m	+22°02'
✱ γ Gamma	★2	4.8/4.8	8"	1^h51^m	+19°03'
λ Lambda	★2	4.8/7.4	37"	1^h55^m	+23°21'
NGC-772	Sp	10.9	5'x3'	1^h57^m	+18°46'
30 Arietis	★2	6.6/7.4	39"	2^h34^m	+24°26'
E Epsilon	★2	5.2/5.6	1.5"	2^h56^m	+21°08'
TAURUS					
✱M-45 Pleiades	OC	1.4	100'+	3^h44^m	+23°58'

✱Detailed in Eyepiece Impressions

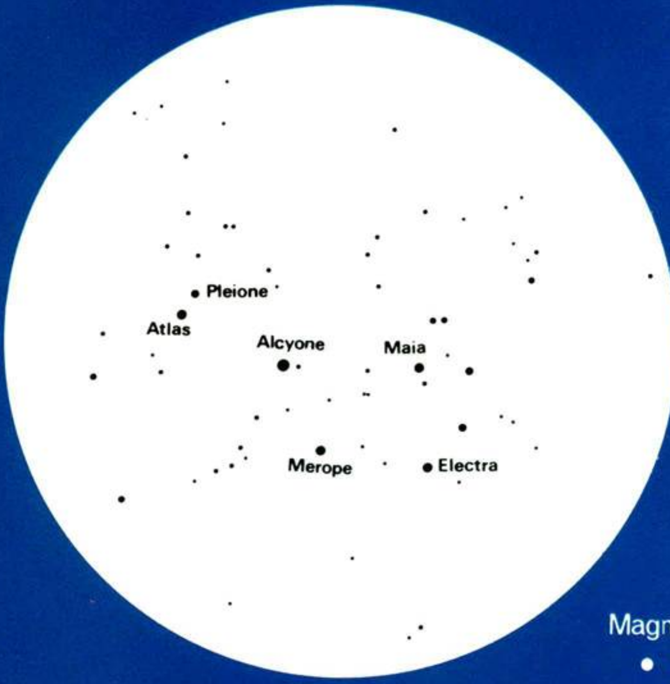
OC = Open Cluster
GC = Globular Cluster
EN = Emission Nebula
RN = Reflection Nebula

PN = Planetary Nebula
El = Elliptical Galaxy
Sp = Spiral Galaxy

Ir = Irregular Galaxy
★2,3,4 = Double/Multiple Star
V = Variable Star
Nr = Nova Star, recurring

Mag. = Magnitude Sep. = Separation

THE PLEIADES



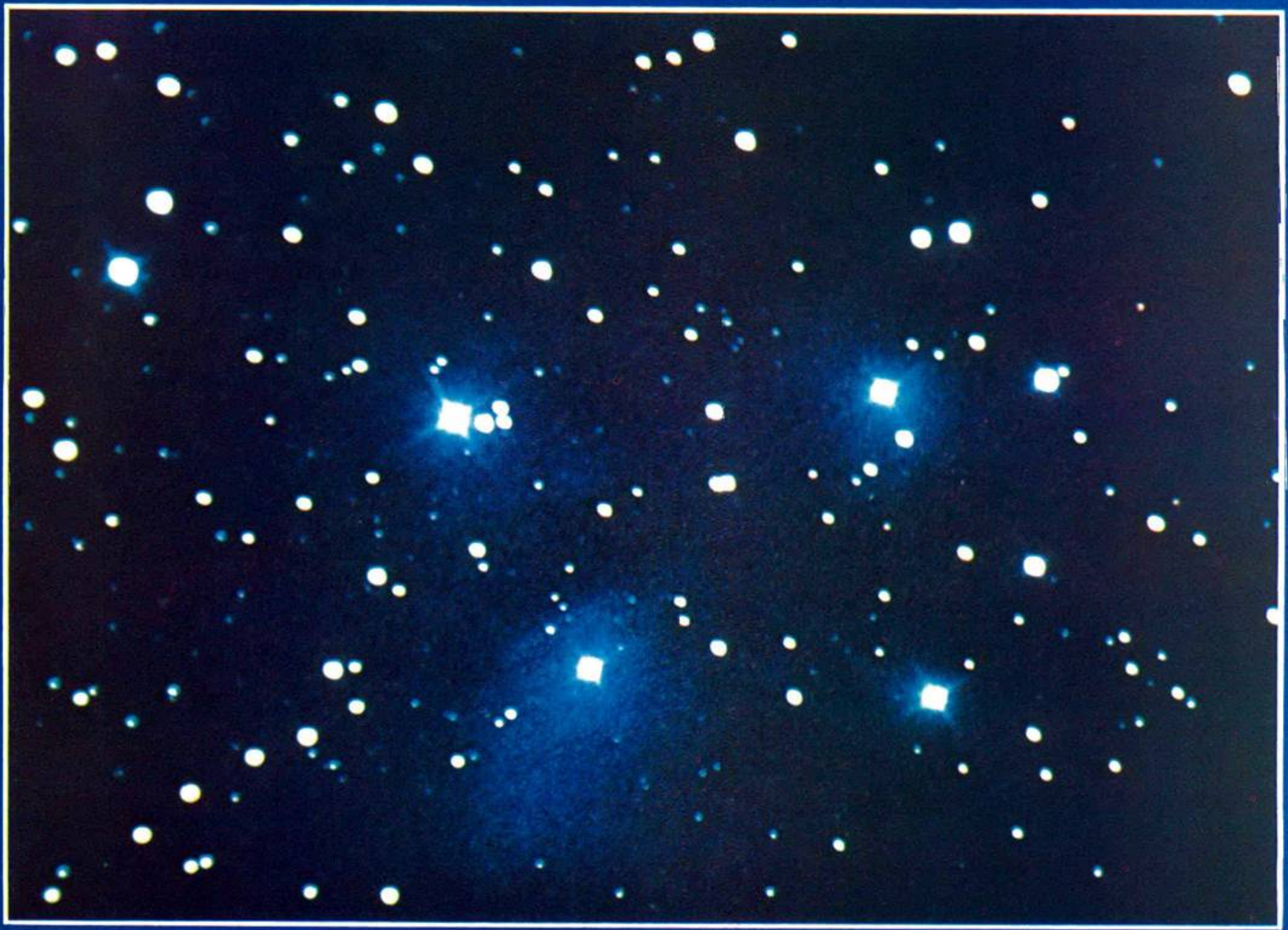
The guided photograph of the Pleiades below shows many more stars than the accompanying map at left, or in diagrams A and B on the opposite page. The photo also shows nebulosity around Alcyone, Merope, Electra and Maia - something few experienced visual observers have been able to see in their telescopes. However, as diagram A suggests - made with a six inch aperture Criterion Dynascope at 50 power - you will find it easier to see the Pleiades' blue and gold star colors. For this purpose, medium to large aperture telescopes are a necessity. But with large aperture, as with the Dynascope f/8 view, the eyepiece field of view is limited to about one degree. You can fully appreciate the extent of the Pleiades with 7 x 50 binoculars. Diagram B represents an erect image (the way you see it in the sky), six degree field of view. An interesting project might be to chart all the stars you see in your telescope or binoculars and compare your drawing to the photograph. Also, on an especially clear winter evening using averted vision, try to detect the Pleiades nebulosity. While you're in the general area turn your telescope toward the double star Gamma Arietis. Diagram C shows a split field of view. Drawn while using a 60mm Unitron refractor, the left hand section shows Gamma at 35 power while the right gives its appearance at 150 power. Above: Photograph by Patrick Michaud; Left: Map by Victor Costanzo; Opposite Page: Diagrams by James Mullaney.

Magnitudes:

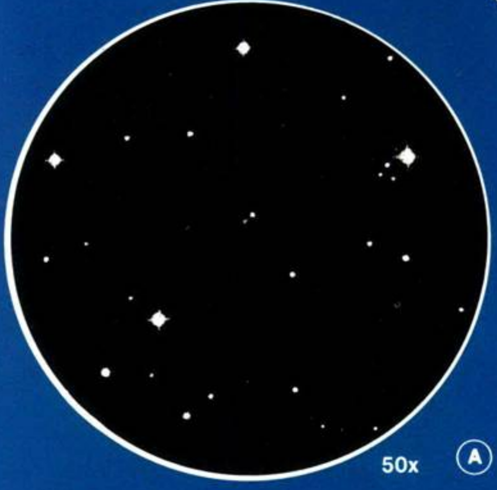
● 3rd
● 4th
● 5th
• 6th
· 7th
· 8th

Scale:

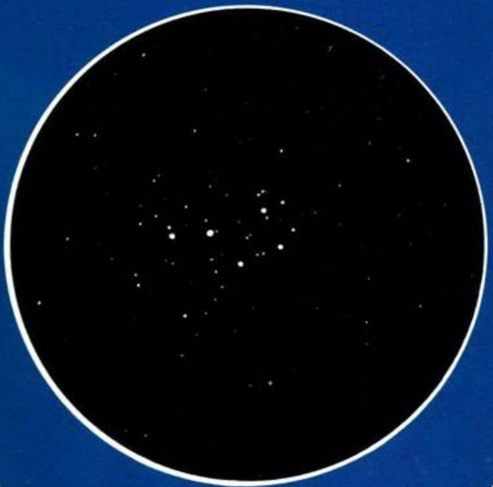
1°



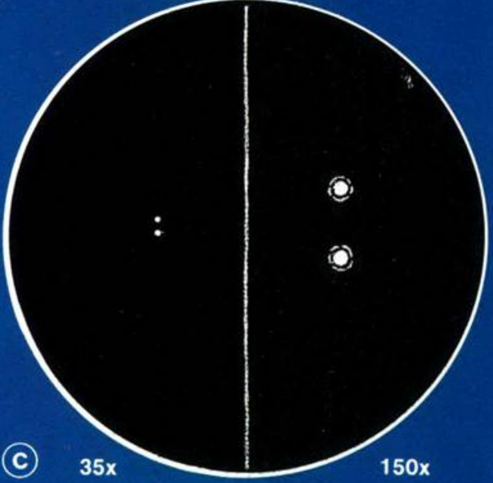
M-45 Pleiades



M-45 Pleiades


7 x 50 Binoculars

Gamma Arietis



tions. All three of these objects are dim *reflection nebulae* — clouds that are visible only by light of nearby stars reflecting from ice and dust particles within them. They are poor reflectors making them extremely faint and difficult to observe. Some observers in the past have suspected variations in the brightness of the Pleiades nebulosity, which implies intrinsic change in the stars themselves.

A four inch reflector at 40 power provides a superb view of M-45 on dark nights and at times shows traces of hazy wisps about several of the stars. A word of caution is needed here, for the cold evenings of winter promote fogging of eyepiece lenses from breath and body warmth. This can cause all of the Pleiades stars to suddenly — strikingly — become very nebulous.

Gamma (γ) Arietis

As the table of objects shows, most of December's attractions are double stars. The showpiece of this region is a beautiful white pair called Gamma Arietis. Lowermost of the Alpha-Beta-Gamma trio of Aries, this object is easy to spot and a fine sight in any telescope.

Consisting of two perfectly matched 4.8 magnitude stars separated by eight seconds of arc, a 2.4 inch (60mm) refractor at 35 power splits them easily. The same instrument at 150 power reveals the spurious diffraction pattern of the components — an intriguing contrast of views as shown in the split field, composite drawing.

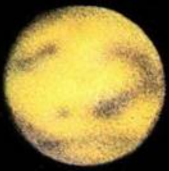
Gamma was one of the first double stars to be recognized as such, and was accidently discovered by Hooke in 1664 while following a comet. He related, "I took notice that it consisted of two small stars very near together; a like instance to which I have not else met with in all the heaven."

Both components look white to most observers. Olcott dubbed them "white and pale gray". Webb said "very white and whitish-yellow", while Smyth saw them as "bright white and pale gray or faint blue".

The Arabic name for Gamma Arietis is Mesarthim. Together with Hamal (Alpha) and Sheratan (Beta), it forms "...quite the most engaging portion of an otherwise indifferent constellation" in the words of Barns. Olcott calls attention to a curious and little-known point concerning Aries: "The pair of stars, Beta and Gamma Arietis, are one instance out of many where conspicuous stars form pairs, the brighter of the two lying generally to the east."

As mentioned in the Close-Up section, Aries once marked the position of the vernal or spring equinox and was of great importance to the ancients. The Pleiades too have been held in awe and reverence throughout antiquity. As we survey the wonders of this region, we sense the truth in the words of Von Humboldt when he said, "The stars bind together all men and all periods of the world's history. As they have seen all from the beginning of time, so shall they see all that will come hereafter."

Planet Finder



Ⓒ Cer

Dec.	1	15
R.A.	$4^{h}27^{m}$	$4^{h}13$
Dec.	+18°13'	+18°
Mag.	+6.7	+6.8

Ⓐ Mercury

Dec.	1
R.A.	$16^{h}36^{m}$
Dec.	-23°05'
Mag.	-0.8

Ⓑ Mercury

Dec.	15
R.A.	$18^{h}21^{m}$
Dec.	-25°28'
Mag.	-0.6

Ⓜ Mars

Dec.	1	15
R.A.	$5^{h}51^{m}$	$5^{h}28^{m}$
Dec.	+25°40'	+26°03'
Mag.	-1.4	-1.5

Ⓝ Neptu

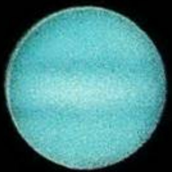
Dec.	15
R.A.	$16^{h}42$
Dec.	-20°45
Mag.	+7.7

SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

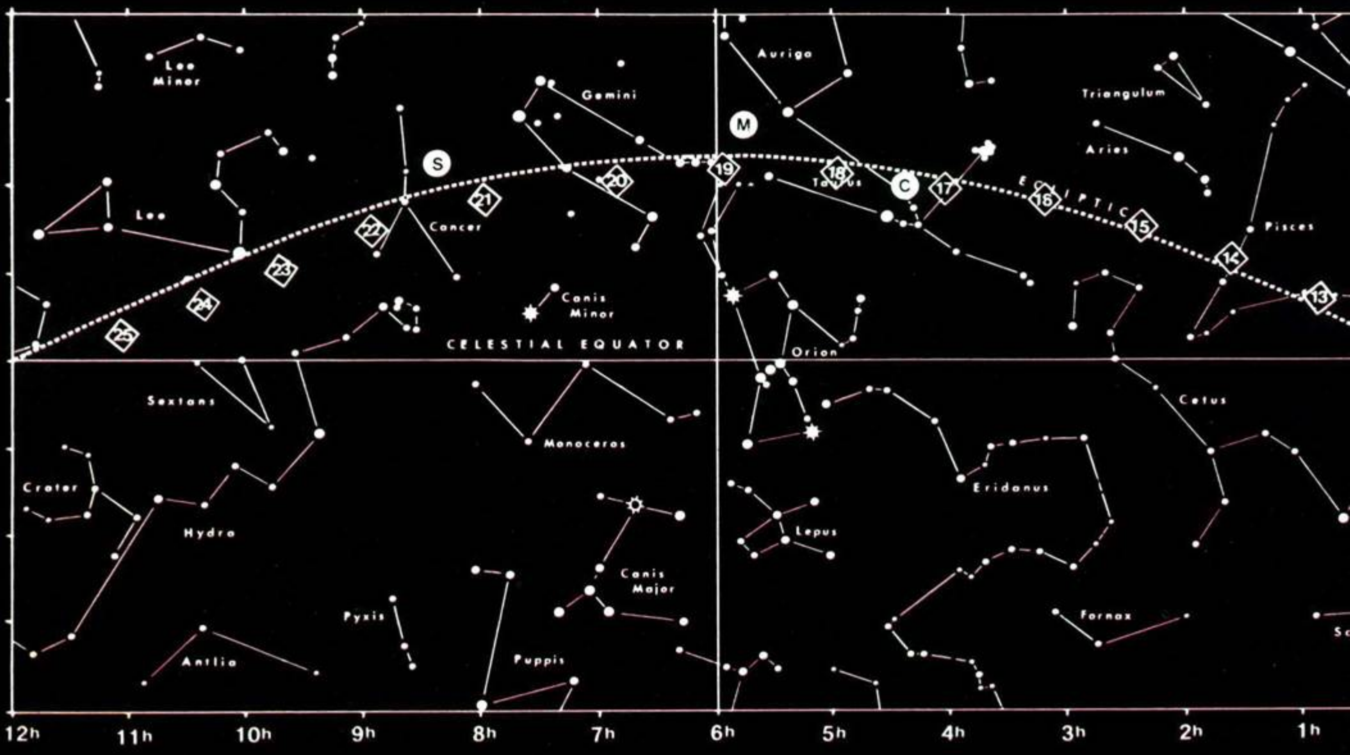
Ⓢ Saturn

Dec.	1	15
R.A.	$8^{h}20^{m}$	$8^{h}17^{m}$
Dec.	+19°43'	+19°55'
Mag.	+0.2	+0.1



Ⓤ Uranus

Dec.	15
R.A.	$14^{h}14^{m}$
Dec.	-12°58'
Mag.	+5.7

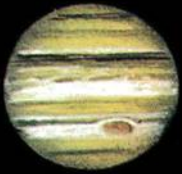

Leo Minor
Gemini
Auriga
Triangulum
Aries
M
S
C
Leo
Cancer
Taurus
ECLIPTIC
Pisces
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Monoceros
Cetus
Crater
Hydra
Eridanus
Lepus
Canis Major
Pyxis
Fornax
Antlia
Puppis
Sc
13
14
15
16
17
18
19
20
21
22
23
24
25
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec . = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag . = magnitude, a

December 1975

Vesta

Dec.	1	15
R.A.	23^{h}29^m	23^{h}49^m
Dec.	-11°35'	-9°40'
Mag.	+7.1	+7.1



Ⓙ Jupiter

Dec.	1	15
R.A.	0^h 57^m	0^h 56^m
Dec.	+4°31'	+4°33'
Mag.	-2.3	-2.2

Ⓨ Venus

Dec.	1
R.A.	13^{h}33^m
Dec.	-7°22'
Mag.	-3.9

Ⓩ Venus

Dec.	15
R.A.	14^{h}35^m
Dec.	-12°39'
Mag.	-3.7

Ⓟ Pluto

Dec.	15
R.A.	13^{h}07^m
Dec.	+11°00'
Mag.	+14

First Quarter

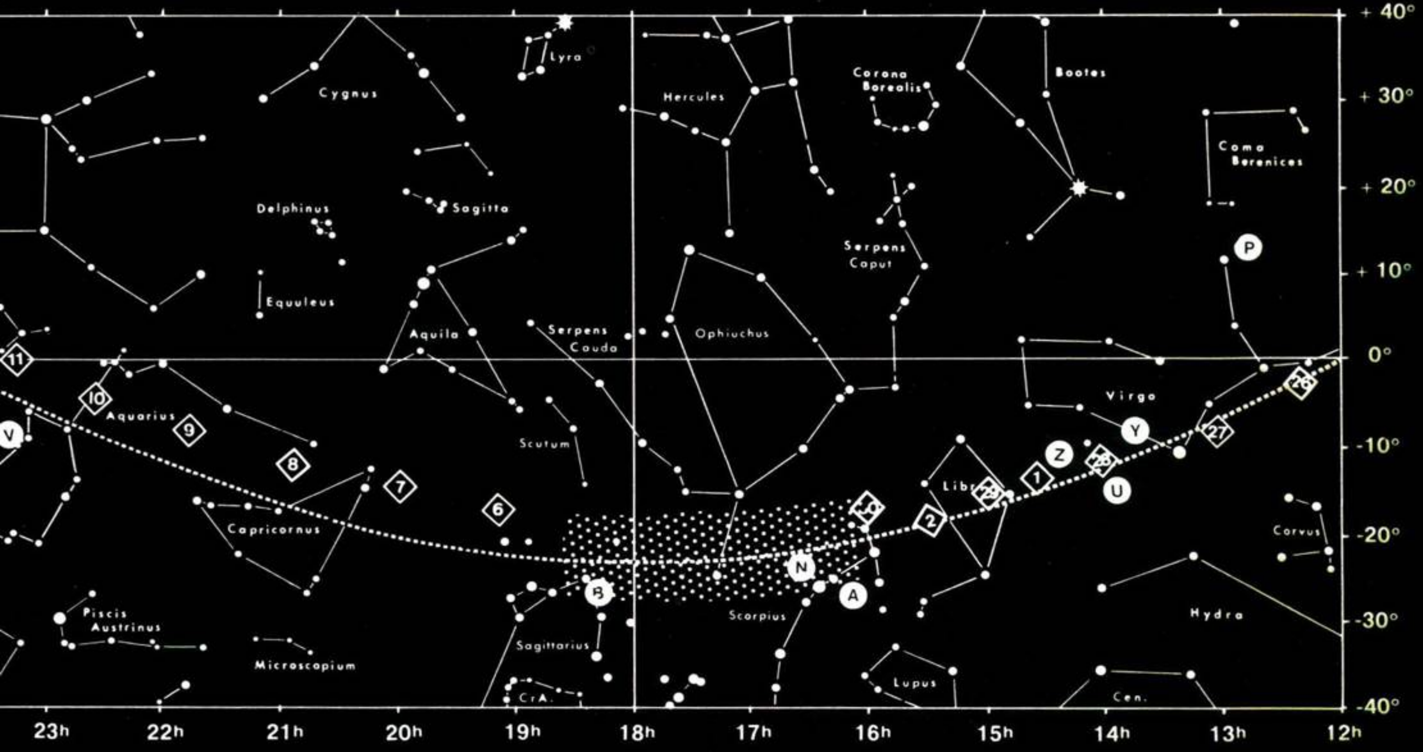
Dec. 10

Full Moon

Dec. 18

Last Quarter

Dec. 25


Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Serpens Caput
Equuleus
Aquila
Serpens Cauda
Ophiuchus
Aquarius
Scutum
Virgo
Capricornus
Libra
Corvus
Piscis Austrinus
Sagittarius
Scorpius
Hydra
Microscopium
Lupus
CrA
Cen.
P
Y
Z
U
N
A
B
V
1
2
6
7
8
9
10
11
15
16
22
23
26
27
+ 40°
+ 30°
+ 20°
+ 10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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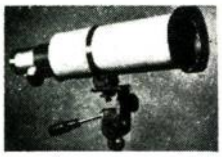

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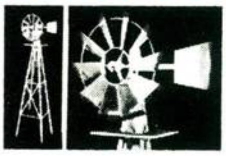
AUTHENTIC SCALED WINDMILLS



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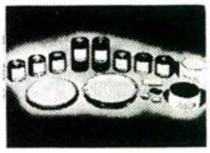
ASTRONOMICAL MIRROR KITS



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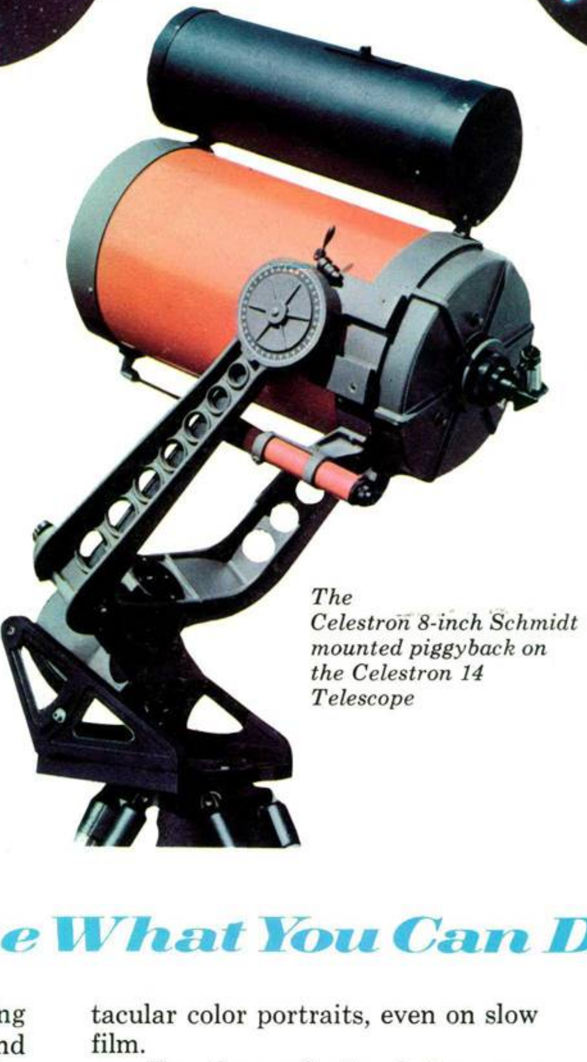
Above, clockwise: The Rosette Nebula, Celestron 5½-inch Schmidt Camera, Kodacolor-X, 15 minutes, Photo by Thomas J. Johnson... The Andromeda Galaxy, Celestron 8-inch Schmidt Camera, GAF 200, 15 minutes, Photo by Thomas J. Johnson... Multiple exposure of lunar eclipse, Celestron 5½-inch Schmidt Camera, Kodacolo II, 1 sec., 6 sec., 1 sec., 1 sec Photo by Dr. James L. Ma teson . . . Comet Kohoute Celestron 5½-inch Schmid Camera, High-Speed Ekta chrome, 3 minutes, Photo b Dennis di Cicco . . . Th Orion Nebula, Celestron 1 inch Schmidt Camera, GA 200, 10 minutes, Photo b Dr. James L. Matteson.



The Celestron 8-inch Schmidt mounted piggyback on the Celestron 14 Telescope

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Three models are available: the 5½-inch, f/1.65, priced at $625; the 8-inch, f/1.5, priced at $950; and the 14-inch, f/1.7, priced at $4,150. All are described in our free color cata log, along with the complete line Celestron compact-portabl telescopes and accessories.

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